THE

JOURNAL OF GEOLOGY

MAY–JUNE, 1899

AMERICAN HOMOTAXIAL EQUIVALENTS OF THE ORIGINAL PERMIAN[1]

In this country the Permian question has long remained open. Its various phases are essentially the same today as they were forty years ago, when Permian faunas were first thought to be identified in the rocks of Kansas. For nearly a quarter of a century comparatively little information was added. Recently, however, active interest in the subject has been renewed, and new data have been acquired. With this revival of interest bob up also all the old questions. Concerning these there is as much difference of opinion as ever. Besides, new problems are presented.

In all of the discussions concerning the American Permian which have taken place in past years certain important facies of the theme have appeared to be wholly overlooked. In the newer considerations there is also a manifest tendency to pass over these very essential qualities. It seems pertinent, therefore, to consider briefly some of these phases of the subject. The following notes and comments are to be regarded as suggestive along the line indicated. No formal attempt is made to correlate in detail the terranes mentioned.

[1] Read before the Geological Society of America, December 28, 1898.

AMERICAN ROCKS ORIGINALLY REFERRED TO THE PERMIAN

Historical note.— Regarding the Permian in this country, three questions are prominently presented: (1) Should the Permian be recognized in America? (2) If so, what is the taxonomic rank of the succession of beds referred to it? (3) What are the upper and lower limits of the terrane so called? These questions are perfectly distinct, though they are usually considered together.

The introduction of Murchison's term Permian into the literature of American geology was due to Meek and Swallow, in 1858. The year previous, Hawn had collected, in central Kansas, the fossils identified by them as Permian forms. The beds from which these organic remains were taken form a part of an extensive sequence that extends in a broad belt from eastern Nebraska, through Kansas and Oklahoma, into central Texas. To this province the present notes refer.

After the first announcement of the discovery of supposed Permian fossils in this region, the subject was frequently discussed during a period of more than a dozen years. Meek, Swallow, Hawn, Shumard, Hayden, Newberry, Marcou, and Geinitz, made the principal contributions. Later White and Broadhead took up the subject to some extent. Recently Cragin and Prosser, in Kansas, and Cummins, in Texas, added much to our knowledge of the rocks in question.

The wholly disconnected character of the work of these authors is unfortunate. Except in a general way, is has been, heretofore, impossible to make any satisfactory comparisons between the different parts of the province. Only recently has any relationship been established between the results obtained by the various explorers of this region. Prosser has been chiefly instrumental in giving us something tangible to work upon. In connection with his own investigations, he has made a special effort to bring some of the earlier acquired results into close correspondence. The upper part of so-called Permian in Kansas still remains rather uncertain as to its natural subdivisions, and its relations to other sections. The lower part and the underlying

"Upper Coal Measures" along the Missouri River, which may be regarded as the standard section, have been lately carefully correlated.

The recent work has been sufficient to give us a good idea of the general character of the deposits regarded as Permian, the stratigraphical succession in the different parts of the province, the range of many species of fossils, and an outline of the main subdivisions that it will be useful to recognize.

Character of deposits.—The beds of the Continental Interior basin that have been considered as Permian, or Permo-Carboniferous and Permian, consist of two heavy shales, separated by thick limestones. The total thickness in Kansas is probably about 2000 feet; in Texas perhaps double this figure.

The lower beds are almost wholly made up of argillaceous and sandy shales, yellow, brown, green, and blue in color, and brown shaly sandstones. Occasionally occur thin, rather impure limestone bands, that carry abundant fossils. Near the bottom of the formation are some workable coals, associated with which is a characteristic flora.

The median number is composed largely of gray and buff limestones, often in thick layers, shaly limestones, and calcareous shales. The heavy limestones contain more or less chert in nodules and discontinuous bands. Abundant fossils are represented.

The upper part consists principally of gray, variegated, and red shales, and shaly limestones. Gypsum and salt deposits occur abundantly. Fossils occur only very sparingly.

In the main, the deposits indicate shallow waters, in strong contrast to the thalassic conditions that prevailed previously in the same regions. The sediments were laid down largely in closed basins, which finally become altogether dry.

General geological section.—In Kansas the general succession, as made out by Prosser and Cragin, is about as follows:

SECTION OF UPPER CARBONIFEROUS TERRANES OF KANSAS

Terrane	Thickness	Character
Kiger shales	210	Shales and sandstones, red chiefly (Upper "Red Beds"), with some gypsum, and thin dolomitic layers.
Cave Creek gypsum	40	Gypsum, massive, with some red shale.
Salt Fork shales	1000	Shales, and shaly sandstones, red (Lower "Red Beds"), with rock-salt and gypsum.
Wellington shales	350	Shales (lower salt measures), variously colored, gray predominating below, and gypsum.
Marion shaly limestones	150	Limestones chiefly, gray and buff, thinly bedded.
Chase limestones	250	Limestones, heavily bedded, much chert, and calcareous shales.
Neosho shales	140	Shales, yellow, green, and brown, with few thin limestone bands.
Cottonwood limestone	10	Limestone, fusuline, buff.
Wabaunsee shales	550	Shales, sandy, argillaceous, with a few thin coal seams.

Relations of Texas section.—In northern and central Texas the beds called Permian are well developed. Cummins separates the succession into three parts, which he terms the Wichita, the Clear Fork, and the Double Mountain, each being regarded about 2000 feet thick. According to this author, the section of the Paleozoic above the lower Carboniferous is:

CARBONIFEROUS TERRANES OF NORTHERN TEXAS

Terrane	Thickness	Character
Double Mountain	2075	Shales, red, sandy, often saline, with some earthy limestones, and much gypsum.
Clear Fork	1975	Limestones, and calcareous reddish shales, some sandstone.
Wichita	1800	Shales and sandstones, and some conglomerates.
Albany	Wanting.	Limestones.
Cisco	840	Shales, with coal beds.
Canyon	930	Limestones, with shales.
Strawn	950	Shales and shaly sandstones.
Millsap	1000	Shales, with coal beds, and shaly sandstones.
Lower Carboniferous		

Just what parallelism should be instituted between the Texas and Kansas beds is not yet quite clear. The apparent enormous

development of the beds in question in Texas as compared with those north of the Wichita range, and the meager information, of an exact kind, regarding the former, make any attempt at correlation little short of guesswork. However, White's fossils, collected in the upper Wichita and lower Clear Fork, indicate an horizon near the Plattsmouth beds of Nebraska. The Albany seems to be very nearly equivalent to the Missourian series below the horizon just mentioned. The Double Mountain beds are, in a broad way, manifestly approximately equivalent to Cragin's Cimarron series. This leaves a considerable part of the Clear Fork beds representing the Chase and Marion of Kansas. There are in Texas indications of an unconformity at the base of the Clear Fork. Should this prove true, as now seems probable, it amply accounts for a number of hitherto inexplicable phenomena connected with the Kansas rocks, above the main limestones of the Missourian.

Organic remains.—It is unfortunate that, with all the advantages that the various workers in the so-called Permian have had, the information regarding the faunas is so meager. Fossils are abundant, at least up to the middle of Prosser's Marion. Such as have been recorded present some interesting phases.

It cannot be gathered from the discussions concerning the fossils found in the Upper Paleozoic west of the Missouri River, in Kansas and Nebraska, just what should be considered the typical "Permian" fauna. The appearance of abundant lamellibranchs and the disappearance of brachiopods seem, as noted elsewhere, to be the most notable features to which attention has been called. Geinitz, considering the fossils found in the Nebraska beds, which he referred to the Dyas, had before him both types. These strata are now known to be partly immediately below the Wabaunsee and partly the very base of the latter. Geinitz did not misinterpret their position so badly as Meek and others would have us believe. His comparisons were made with European standards, and if such comparisons can have any value at all they indicate a degree of acumen on the part of the German paleontologist that few Americans credit him.

Meek's exhaustive criticism of Geinitz's work on the Nebraska faunas, and his other papers on the same subject, appear to be largely misinterpreted by later writers. So far as I am able to find out, Meek's efforts were not directed so much against the view of the Permian age of the Plattsmouth beds as they were to emphasize the fact that the faunas followed one another uninterruptedly from the "Upper Coal Measures" up to the "Red Beds." He was unable to see how a "new and distinct system" could be represented in such a perfectly continuous sequence.

The case of Meek and Swallow is different. It was, after all, a mere quibbling about unimportant details. With all their bitter controversies, their views were not very far removed from each other. Their subdivisions were practically the same. Only different names were employed. Swallow regarded the Paleozoic section above (approximately) the Cottonwood limestone, as divided into Lower Permian and Upper Permian. Meek, selecting dividing horizons slightly different, called the one Permo-Carboniferous and the other Permian. Both agreed in the upper member being Permian. Regarding the lower member, Swallow thought Permian fossils predominated; Meek considered species of the Upper Coal Measures more abundant. Neither seems to have presented any decisive proofs one way or the other.

Prosser's late classification of the central Kansas rocks claims to be based upon the faunas. The subdivisions are properly given special geographic names, but the division lines are very nearly the same as those selected by the earlier writers. The faunal evidence, as Prosser has set it forth in detail, appears to oppose, rather than to support, the conclusions he has drawn.

Range of fossils.—In all the faunal considerations that relate to the Upper Paleozoic of Kansas, the rapid disappearance of the brachiopod fauna "characteristic of the Upper Coal Measures," and its replacement by a "Permian" lamellibranch fauna, is pointed out as very significant. Such a comparison is hardly justifiable. The two cannot be thus contrasted any more than a fauna with a flora. They have no common points of relationship. The appearance of the latter in place of the former indicates a

change in physical conditions, but in this case nothing more. Similar and even more marked changes occur at a hundred different horizons in the Carboniferous lower down. When shallow waters prevailed, lamellibranch and gasteropod faunas occupied the areas. When pelagic conditions occurred, the occupants of the district were chiefly brachiopods. The latter moved in as the former moved out. Comparisons of faunas of different classes avail little; they must be of the same class if tangible results are to be expected.

In drawing conclusions regarding the fossils of the beds that have been referred to the Permian and the Permo-Carboniferous, the utmost caution is imperative. The terranes have been only very imperfectly and very unequally explored. Comparisons of faunas have been largely between zoölogical groups of different classes. Many of the beds in the general vertical section are understood only in a vague way. There are long intervals about which nothing either stratigraphically or faunally is known. With a few isolated exceptions, organic remains have yet been found only in the lower half of the succession. Fossiliferous beds reach, according to our present knowledge, only up to the middle of the Marion. In Texas the "Permian" fossils described by White and Cope were from the Wichita and Lower Clear Fork beds.

Taking the fossils, the horizons of which are definitely known, and as chiefly determined by Prosser, fifty-two species are recorded from the Wabaunsee. Of these only two new ones occur in the Cottonwood. In the Neosho following, one third of the twenty-one species noted are not reported from the lower beds; they are lamellibranchs. In the Chase eleven of the thirty-three species appear for the first time. The Marion contains fewer species, but they are forms occurring at lower horizons. The principal brachiopods run through the whole sequence.

THE ORIGINAL PERMIAN

Historical statement.—The Upper Paleozoic rocks occurring along the western flanks of the Urals, in eastern Russia, in

Europe, were thought by Murchison to constitute a distinct system, equal in rank to Carboniferous and Silurian. He named it, in 1841, after the ancient kingdom of Perm. Since that time much has been learned regarding this great terrane in the Russian provinces. Numerous comparisons have also been made with supposed equivalents in other parts of the world.

A notable fact regarding the Russian Paleozoic rocks above the Devonian is that in nearly every respect they are very similar to those forming the same part of the general geological section developed in the Mississippi Valley. The original Permian presents almost the identical features that do the beds so called in Kansas and Texas. And, strangely enough, the identical questions that have arisen in this country are bones of contention among Russian geologists.

Those who took part in the long excursions in eastern, central, and southern Russia before and after the sessions of the Seventh International Congress of Geologists, held in St. Petersburg in August 1897, had ample opportunity to study the original Permian under the most favorable circumstances. Under the personal guidance of Messrs. Karpinsky, Tschernyschew, Pavlov, Amalilsky, and Nikitin, especially, the typical and critical sections were examined and the fossils of the various horizons collected. With the aid of the official maps, such literature of the region as was at hand, and the explanations offered by the geologists mentioned, who with others had worked in the district and were well acquainted with the details, an unusually good idea of the Russian Permian was obtained.

To those from America, who were especially interested in the Carboniferous and Permian, this experience furnished much desired information. The similarity of the deposits, of their faunas, and of the questions concerning them, in the Russia and Mississippi provinces, seems to make some comparison of their features worthy of formulation. The bearing that a direct knowledge of the former has upon the latter will certainly tend to make our own problems easier of solution.

Distributions of the terranes.—The Carboniferous and Permian

rocks of Russia extend from the Arctic Ocean to the Black Sea — a distance of 1500 miles — and from the Urals westward a distance of 1200 miles. In the central and southern parts of the area is a thin covering of Cretaceous and Tertiary deposits. This vast basin, with its nearly horizontal strata, is comparable to our own Carboniferous basin of the Mississippi valley. In the latter region the lower portion of the sequence — or Coal Measures — predominates. In Russia the upper part, or Permian, forms the surface in most of the region.

Around the margins of the great basin, especially on the west and east sides, the Carboniferous is well developed. The lower Carboniferous, made up of limestones, is well displayed, lying immediately upon the Devonian. Relatively speaking, the Coal Measures are not very well represented, though the southern coal field, or Donetz basin, covers 1200 to 1500 square miles, and the central field, or Toula basin, has about the same area. On the flanks of the Urals some coal is also found.

The most typical sections of the Permian are in the Kama River Valley. The great Volga Valley, above Samara, is occupied chiefly by the so-called Permo Trias.

Nature of the rocks.—The beds that are called Permo-Carboniferous, Permian, and Permo-Trias, which occur in the Kama River Valley present the most typical phases of Murchison's "system." The whole succession is tripartite. Shales, sandstones, and marls are separated medially by heavy dolomitic limestones.

The lower member consists of argillaceous and sandy shales, shaly sandstones, marls, and some impure limestones. Sometimes conglomerates are present. Abundant fossils are represented. Upwards of 300 species have been listed. A distinctive flora is also present.

The median terrane is made up chiefly of massive dolomitic limestones, separated by calcareous shales. It forms a striking contrast to the beds above and below.

The upper member is formed of variegated argillaceous and sandy shales, brown shaly sandstones, some of which are copper-bearing, marls, and occasionally thin limestone bands. Gypsum

is also frequently disseminated. The inferior portion is fossiliferous. Above this part come other shales, marls, and sandstones, almost destitute of fossils. They are thought by some authors to be Triassic.

The passage from the prominent marine phase of the Uralian Carboniferous to the subsequent shallow-water conditions is remarkable. The same closed basin depositions are as noteworthy as in the case of the American.

General section.—The Paleozoic beds above the strictly marine Carboniferous, as made out in the Ural region, are grouped by the Russian geologists in the following way:

UPPERMOST PALEOZOIC TERRANES OF EASTERN RUSSIA

Terrane	Symbol	Character
Tartaran	PT or P_3	Shales and marls, "Red Beds," very few fossils.
Zechstein (in part)	P_2	Marls, limestones, and sandstones.
———	P_b	Sandstones, shales, and marls with nodular limestones).
———	CP_c	Dolomitic limestones (base of Murchison's Permian).
Artinsk	CP_2	Shales, shaly sandstones. This and next terrane above are called Permo-Carboniferous.
———	C_3	Limestones.

Faunas represented.—The so-called true Carboniferous of the Urals is made up almost entirely of limestones. The highest member symbolized by the Russian geologists, C_3, contains a prolific fauna, which, while chiefly brachiopodous, has also a good representation of corals, some lamellibranchs, and fusulinæ.

Following, are the transition faunas to the Permian, according to the Russians, and by them called Permo-Carboniferous. The two members which comprise it contain, as pointed out by Tschernyschew, very nearly the same organic forms, consisting largely of lamellibranchs, gasteropods, and brachiopods. The lower terrane, termed the Artinsk, is notable for the ammonites that are found in it, which the author just mentioned compares with those lately found in the Texas Permian. The upper

terrane (CP_c), made up of dolomitic limestones largely, is the basal number of Murchison's original Permian.

The bottom terranes of the Permian, as now recognized by the members of the Russian geological survey, present a great paucity of fossils. The forms are chiefly lamellibranchs, yet in some layers are fragmentary plants.

The median part of the Permian carries what has been regarded as the typical German Zechstein fauna.

About the upper terrane there is much dispute as to age. The Russian geologists are about equally divided. Amalitzky considers it Permian. By others it is regarded as Triassic. Fossils occur rarely. Those found are chiefly lamellibranchs.

Base of Murchison's Permian.—As already noted incidentally, the lower limit of the original Permian, as established by Murchison in 1841, is the bottom of the dolomitic limestone immediately overlying what is called the Artinsk terrane. The geologists who have worked in the region place this line in the middle of the Permo-Carboniferous. The succession of strata and the sequence of faunas are continuous from the Carboniferous to the Permian. The transition is so gradual that it appears impossible to locate a satisfactory line of division between the two. The conditions are identical with those that we have encountered in this country, and, following our example, the Russians have adopted our term — Permo-Carboniferous.

While the adoption of such a course emphasizes the transitionary character of the faunal sequence, it complicates, rather than simplifies, matters. Two important divisional phases are recognized, both of which are as vague and unnatural as the one that this plan aims to obviate. On all other than faunal grounds, Murchison's lower limiting horizon of the Permian is the most satisfactory and perhaps also the most natural.

COMPARISON OF THE RUSSIA AND MISSISSIPPI VALLEY CARBONIFEROUS

Stratigraphic parallelism.—In Russia and in the Mississippi valley the general geological sections of the upper Paleozoic

are remarkably alike. The basins occupied by these rocks are very nearly of the same size. As already stated in the first-mentioned area, the Permian very greatly predominates as the surface rock. In the last-named, the coal measures. The Carboniferous of Russia presents two very distinct aspects—a thalassic facies, occurring on the western flanks of the Urals, and made up of limestones chiefly; and a shallow water or littoral phase, that is coal bearing, and that is best developed in the southern and western parts of the great area, principally in the Donetz and Toula basins.

COMPARISON OF GENERAL SECTIONS

Russia	Character of Terranes	Mississippi Valley
Tartaran, Permo-Trias, or Upper Permian, P_3	Shales and marls, red and variegated, shaly sandstones; fossils rare; "Red Beds"	Cimarron Series
Middle Permian, P_2	Limestones, some dolomitic, separated by calcareous marl	(Marion li.) }
Lower Permian, P_1-b	Shales (only 200 feet thick in Kama Valley)	——— ? } Series
Upper Permo-Carboniferous (base of original Permian) CPc.	Limestone, heavy dolomitic	(Chase li.) }
Artinsk, CP.	Shales, sandstones, some thin limestones	(Neosho) (Cottonwood) (Wabaunsee) } Series
Upper Carboniferous, C_3	Limestones and shales, highly fossiliferous	Missourian Series
Moscouan, Middle Carboniferous, C_2	Shales, sandstones, thin limestones, coal-bearing	Des Moines Series
Lower Carboniferous, C_1	Limestones chiefly, some shale and sandstone	Mississippian Series

In the consideration of a theme like the present one, it is recognized at the outset, that comparisons of terranes of different geological provinces involves no necessary exact synchrony, except through absolute physical means of correlation. Such a standard, independent of intrinsic features of the terranes themselves, is not yet formulated for widely separated districts. The shortcomings of the common fossil criteria, in any other than the most general way and in the absence of something better, are well known. Any agreement of biotic features in stratigraphic successions distantly removed from one another are looked upon, so far as indicating simultaneous origin, only as happy accidents. Instead of furnishing proofs of time equivalency, it suggests for similar faunas only likeness of conditions, irrespective of time. Such faunal facies are only representative. They are merely homotaxial.

Any similarity of lithological succession is likewise accidental. The same is manifestly true of any other agreement of intrinsic features.

Nevertheless, a comparison of general geological sections in provinces so widely separated as the two under consideration, and so wholly distinct from each other in their origin, can be made not only suggestive but very profitable. The same problems for solution arise in both districts. The naturally different manner of treatment is mutually helpful in the solution of the various difficulties that are presented. Misconceptions regarding each are dispelled. Greater independence in the consideration of succession is established.

The most remarkable fact connected with the Russian section of the Upper Paleozoic and that of Kansas is that the two should be capable of any comparison at all. While the two differ much in stratigraphic, lithological, and biotic details, in general all three classes of characters present a very similar sequence.

Lithological features.—In the Russian and American Permian provinces, the field appearance of the rocks is very strikingly alike. This is particularly true of the upper half of the two sections. The general features are lost in the local examinations.

In the Russian district one finds it difficult to imagine that he is not wandering through some part of Kansas. Only the presence of the Russian peasant, or sudden contact with a village of the steppes dispels the illusion. In the Upper Paleozoic the aspects of the limestones and shales, their succession and expression are the same on the banks of the Volga or Kama as they are in the bluffs of the Missouri or Kansas rivers.

The original Permian strata are indistinguishable, lithologically, from the so-called Permian of Kansas. In both there are the same gray and variegated sandy shales and marls, passing locally into sandstones, that are often copper-bearing. Occasionally there are present thin bands and beds of buff earthy limestone. Gypsum is abundantly developed in beds and interspersed everywhere through the rocks. Saline shales are of not infrequent occurrence. On both continents all these pass upward into "Red Beds," that are almost destitute of fossils. Whether the last mentioned strata are Permian or Triassic is still, in both countries, an open question.

Range of faunas.—The succession of faunas appears to be essentially the same in the Russian Carboniferous and Permian as in the Mississippi valley. The composition of each of the faunas is also strikingly comparable. The most noteworthy feature of the organic remains, viewed as a whole, is the gradual replacement of a purely marine type by a shore and brackish water phase, as the change from open sea to closed water conditions took place, and finally to those in which life could not exist.

The most prominent characteristic of the biotic change from a Carboniferous phase to a Permian one seems to be the replacement of a predominantly brachiopod fauna by one in which lamellibranchs formed the preponderant element. This change has not, however, the deep significance usually attached to it. There are many other factors that appear to be largely or entirely overlooked. Faunal considerations should dwell more particularly on some of these other features, rather than upon a detailed tabulation of specific sequence.

The chronologic equivalence and comparison of rocks being universally based almost wholly upon the standard of the fossils is at best a very uncertain criterion. In the case of the Permian this uncertainty has been increased tenfold on account of the peculiar treatment that the fossils have received. The investigation of the biotic characteristics of the Upper Paleozoic has been very unsymmetrically developed and very unequally carried out. This is true in both Russia and America. From the published material no comparison of faunas is really possible; that is, in the sense that modern work demands. This chaotic condition of affairs is not anomalous. It occurs with many other faunas from many different horizons. In the present instance it is merely accentuated by a combination of accidental circumstances.

A most noteworthy factor is the extreme local character of the well known, published information. A single American instance suffices for illustration. Our best knowledge of the faunas of the Upper Coal Measures (Missourian) is derived almost entirely from a single horizon, at the single locality of Plattsmouth, Nebraska. This place has been made classic by Geinitz and Meek. All faunal comparisons, made through secondary means, of the rocks of the Mississippi valley above the lower productive Coal Measures (Des Moines) can take into consideration only the little pamphlet of Geinitz and the thin volume of Meek. Much has been made of this horizon by Waagen, Tschernyschew and other foreign paleontologists. Our American workers among the fossils have also depended largely upon the same sources of information.

As a matter of fact, the fauna of the Plattsmouth is characteristic not of a single, insignificant terrane, but of the entire Missourian series, and upward almost to the limits of the fossiliferous zones of the upper Paleozoic of the region — that is to the Marion. To be sure, as to numbers, the various species are differently represented at the several horizons; some forms are not reported yet from this level or that one; others appear that are not recorded from the Plattsmouth beds; yet, for a region in which no effort has ever been made to exploit systematically

the various horizons, and for a great succession of abundantly fossiliferous beds in which our published information is meager in the extreme, it is remarkable through how great a vertical interval the main characteristics of this Plattsmouth fauna are preserved.

The Plattsmouth remains are referred to as forming a characteristic maritime fauna. So it is, but it is identically the same fauna that is found at half a hundred other horizons between the lower coal measures and the "Red Beds." Whenever the heavy limestones occur the same groups of brachiopods appear. Whenever the more argillaceous shales are found the same lamellibranchs begin to predominate. Where the sandstone and coal-bearing shales are prominently developed coal plants and peculiar lamellibranchs and gasteropods are in evidence. These distinct faunas succeed one another in the same vertical section. They are repeated scores of times. Pretty nearly the same phenomena appear to obtain in the great Carboniferous basin of eastern Russia. In both regions the gradual replacement of the brachiopodous fauna by a "Permian" lamellibranch fauna follows the local change of open to closed sea conditions.

The Permian element of these faunas was merely a shallow water facies of the more typical Carboniferous fauna. It oscillated horizontally back and forth with each local change of bathymetric conditions. It was repeatedly intercalated between horizons carrying the greater thalassic phase. Meek's contention for the fauna of the Plattsmouth beds was for its identity with the fauna of the upper coal measures of the region. He was right. In his argument for the Permian character of the same fossils Geinitz was not wholly wrong. The point of vantage of each was merely slightly different. Could they have consulted more fully, they would have been no doubt soon in close agreement.

TAXONOMIC RANK OF THE PERMIAN

Principles of geological classification.—It is a well-known fact that the modern classifications of animals and plants are based primarily upon genetic relationship. A natural arrangement of

rock terranes is likewise genetic. It is strictly a function of cause and effect. It is only regarding the position of any particular component in a classification, that is subject to a difference of individual judgment. The taxonomic rank of a group may be subject to change as knowledge increases. Among organisms an advancement in rank is frequent. Families eventually attain the rank of orders; genera of families; smaller groups are classed as genera. The same is true of geological formations.

Recognizing, in the taxonomy of rock terranes, the five taxonomic ranks of group or assemblage, system, series, stage, and zone, as amply sufficient subdivisions, at least for all practical purposes, a succession of beds at first given only the rank of a stage may be subsequently advantageously raised to that of series. Stage is a local unit; while series is a provincial one; and system essentially universal.

In applying these principles to the Permian, the question resolves itself into two distinct phases: What should be considered the taxonomic rank of the original Permian? and What is the rank of the succession of beds in this country, referred to the Permian?

Taxonomic position of the Original Permian. — Regarding the rank of the so-called Permian in general, there is much difference of opinion. The older school of geologists, that is permeated thoroughly with the idea that fossil faunas are exactly recognizable the world around, and that we can by them and without effort synchronize the provincial rock successions of different continents, is inclined to recognize in the Permian a universal extension, and to assign it a rank of a system, comparable to Carboniferous or Devonian. The more modern school of geological investigators, that tests classification and correlation by more that a single standard and that is seeking exact results and genetic relationships, would consider the original Permian as a provincial succession, and give it the rank of a series, under the more comprehensive system of the Carboniferous.

If one were to attempt anew to classify the upper Paleozoic deposits of eastern Russia, following the criteria that we have adopted in this country, he would have no hesitancy in assigning to the Permian of that region the rank of a series, and make it a subdivision of the Carboniferous. There is, however, a strong possibility of three or more well marked members being recognized in the original Permian succession, the rank of each of which is certainly higher than that of stage. The uppermost, or Tartaran, division is an example. This may prove to be Triassic in age. The inevitable tendency to advance the rank of such divisions, with the progress of knowledge regarding them, makes it almost certain that the divisions mentioned as having the same rank as the Tartaran, will be eventually regarded as series. Permian will then have to be either advanced to the rank of system, or to a new order intermediate between system and series. The latter course is manifestly not only unnecessary, but undesirable, and according to our present principles, unnatural. The former course is of very doubtful utility, and not feasible on account of the almost universal apathy on part of geologists to increase the present number of recognized systems. When the time comes to regard the present divisions of the original Permian as distinct series, Murchison's term will be, in all probability, quietly dropped. It would appear then, that all things considered, the original Permian can be at best only regarded as a series, and a part of the Carboniferous. The term like many others will then only have an historical significance.

Subdivisions of the so-called Permian beds of the Mississippi valley.— Most Americans, who are at all familiar with the subject, are inclined to regard the beds referred to the Permian as forming a main division of the Carboniferous. The text-books, as a rule, express this view also, and subdivide the Carboniferous system into three parts, the Sub- or Lower Carboniferous, the Coal Measures, and the Permian. With the recent general adoption of the more systematic method of stratigraphic nomenclature and a tendency to impart technical exactness by the use of geographic names, the first named division in this region has

been called the Mississippian series. In its broadest sense the so-called Lower, or Productive Coal Measures finds satisfactory expression in the Des Moines series. For the "Upper Coal Measures" nearly to the usually selected horizon for the base of the Permo-Carboniferous, Missourian has been suggested as a serial name.

The uppermost division of the Paleozoic of the region, the part widely designated as the "Red Beds," has received the title of Cimarron series. It appears to form a tolerably compact sequence, though there is still some dispute as to its exact geological age. Between the Cimarron series and the Missourian series are two other terranes that are well defined. One is composed of the Chase and Marion of Prosser, in part, and the other of the Wabaunsee, Cottonwood, and Neosho.

Should some such subdivision of the Upper Paleozoic be found applicable over the larger portion of the Mississippi basin, as now seems likely, the use of Permian and Permo-Carboniferous will be rapidly discontinued, or will be invoked only in historical reference.

RELATIONS OF "UPPER PERMIAN" TO TRIASSIC

There is little satisfactory data upon which to correlate the beds called Triassic in eastern United States with other regions. The determinations appear to have been largely made upon lithological grounds and plant remains. There is no real physical relation between the Triassic, or Newark in the main, of the Atlantic border, and the Triassic of the region lying to the east of the Rocky Mountains.

The "Red Beds" of Kansas and Texas are thought by some writers to be Triassic in age; by others Permian. In the almost total absence of fossils in these beds, the lithological characters and general red coloration have been resorted to as criteria. Of late the question has been taken up anew. Prosser has been led to believe that the greater part of the Kansas "Red Beds" are Triassic. Williston, from even more reliable data, is inclined to regard the lower part at least as Paleozoic.

The question bids fair to remain unsettled, until some data more tangible and critical are obtained. The deposits of the Triassic of this region were laid down nearly under the same conditions as some of the so-called Permian, The beds appear to have been formed without interruption of sedimentation in enclosed basins. Vertebrate and plant remains are to be expected to form the prevailing forms of life. They cannot be very well compared with marine invertebrate faunas. Such a comparison would, if attempted, prove unprofitable. The clue must be evidently sought in physical criteria, and in the stratigraphy of the region. Sufficient work in this direction has not been done. The exact line of demarcation between the two must therefore remain undetermined for the present.

While this question is brought up at this time with the full knowledge that it has little bearing upon the main theme here presented, it is alluded to for the express reason that the same problem that has come up in connection with the deposits with which we have been comparing the American so-called Permian, has troubled the Russian geologists in their study of the original Permian area. Their Tartaran "Red Beds" are as perplexing as ours; and the opinions as to age are equally divided. Several writers, notably Karpinsky, Nikitin, and Tschernyschew are of the opinion that these deposits were laid down in isolated inclosed brackish water lakes, that continued to exist into the Triassic period. On the other hand, another group of equally shrewd observers, headed by Amalitzky, Schtukenberg, Netchaiev, and Krotov, regard all of these beds as Paleozoic. For all practical purposes the views of the last mentioned workers appear most reasonable.

In this country, the conditions appear identical with the Russian. Amalitzky's idea is equally applicable here, unless it is shown that marked and widespread unconformaties exist near or at the top of the American "Red Beds" and that the undoubted Triassic can be thus clearly separated.

RECAPITULATION

Returning to the original questions, propounded at the beginning, all available evidence appears to indicate :

1. That while we have in America a great succession of deposits identical in all essential respects to the original Permian of Russia, the two great basins merely had similar histories that are not necessarily connected, and doubtless were wholly independent of each other and unrelated ; that the Russian Permian constitutes a geological province by itself ; and that therefore the term Permian should not be used as a technically exact term in connection with the Mississippi valley deposits.

2. That Permian, as originally proposed, applies to a provincial series, and according to our usual standard has at best a taxonomic rank below that of system. Also, in view of the possible elevation of its main subdivisions to the rank of series, the term will have no position in the general scheme of classification. It will be no doubt eventually dropped altogether. The various series belonging to the succession and now having lower rank, will be considered main subdivisions of the Carboniferous system. In this country the same plan has been already proposed.

3. That, with the solution given to the second question, it is unnecessary to attempt to locate the limits of the so-called Permian in this country. The divisional lines of the series comprised in the typical American section in Kansas are already well defined, with the possible exception of that of the uppermost member.

CHARLES R. KEYES.

CORRELATION OF THE CARBONIFEROUS ROCKS OF NEBRASKA WITH THOSE OF KANSAS

IN THE JOURNAL OF GEOLOGY the writer published in 1897 an article on the "Comparison of the Carboniferous and Permian Formations of Nebraska and Kansas"[1] in which he correlated the formations found in Nemaha, Otoe, and Cass counties of southeastern Nebraska with those of eastern central Kansas. At that time comparatively little work in areal geology had been done in northeastern Kansas, the Cottonwood limestone being the only formation that had been even approximately traced from the Kansas River north to Nebraska.[2]

The correlation of the formations in the above paper was based entirely upon their lithologic, stratigraphic, and faunal characters, for the writer did not have an opportunity to trace the distribution of any of the formations to the north of the Kansas River or to study the geology of the region between that river and Nemaha county, Neb. The rocks to the west of the Missouri River, covering the eastern part of Nemaha, Otoe, and Cass counties, were correlated with the Wabaunsee[3] forma-

[1] *Op. cit.*, Vol. V, No. 1, p. 16, and No. 2, p. 148.

[2] See "A reconnoissance geologic map of Kansas," in the Univ. Geol. Surv. Kans., Vol. I, 1896, Pl. XXXI.

[3] Since this article was written a paper has been published by Dr. Charles R. Keyes, in which he substitutes the name "Atchison Shales" for the Wabaunsee formation (Am. Geologist, Vol. XXIII, pp. 304, 309, 310.) The claim for the priority of Atchison shales rests upon the fact that, in 1873, Professor G. C. Broadhead published, under the general title of "Upper Coal Measures," the following heading for a section of the Upper Carboniferous rocks: "General vertical section of Upper Coal Measure rocks below the Atchison county group" (Geol. Surv. Mo., Preliminary Rep. Iron ores and coal fields, 1872, Part II, Geol. Northwestern Mo., chap. iv, p. 88.) In this chapter there is no description of the "Atchison county group" or further reference to it. Chapter xiv of the report by Professor Broadhead is devoted to a description of the geology of Atchison county" (*ibid.*, pp. 376–388); but there is no mention of "Atchison county group" in the entire account, and it is stated under the heading of the "Upper Carboniferous" that "the rocks of this county belong to the

tion of Kansas; while a massive *Fusulina* limestone west of Auburn, Nemaha county, was regarded as the Cottonwood limestone.

It remained, however, to trace these formations from the Kansas River Valley into Nebraska in order to fully demonstrate the accuracy of the above correlations. Fortunately the recent areal work of the University Geological Survey of Kansas has nearly completed this part of the proof. As the classification of the formations of southeastern Nebraska has an important bearing upon the Permian question of Nebraska and Kansas a synopsis of the results of this work will be of interest. During the summer of 1898, Mr. J. W. Beede of the University of Kansas, traced the Burlingame limestone from the Kansas River,

upper part of the Upper Coal series, and include limestones, sandstones, and shales, amounting to about 180 feet in thickness" (*ibid.*, p. 379). Dr. Keyes gives the thickness of the Atchison shales as 500 feet on the Missouri River, and describes the stage as composed mainly of shales with a stratum of coal near the base (*op. cit.*, p. 310). In Kansas the Wabaunsee formation is composed of massive limestones separated by calcareous, argillaceous, and arenaceous shales. (See the writer's description of the formation in JOUR. GEOL., Vol. III, pp. 688–697.)

The only other reference to the Atchison county group in Professor Broadhead's papers, known to the writer, is in his article on the "Coal Measures of Missouri," where he revised and quoted the section from the 1872 report, with this introductory sentence: "The following is a vertical section of the Coal Measures below the Atchison county beds" (Mo. Geol. Surv., Vol. VIII, 1895, p. 360). On page 377 is a brief description of the highest rocks in the state, which are said to occur in "Atchison and the northern part of Holt county," but as far as a formation name is concerned, they are put under what is termed "Group A," and there is no mention of Atchison county group or beds.

In view of the above facts it does not appear to the writer, in the first place, that the name "Atchison county group," used by Professor Broadhead in 1873, was ever defined as the name of a formation; and, secondly, that the name "Atchison shales," proposed by Dr. Keyes in 1899, is not entitled to be substituted for the Wabaunsee formation described by Prosser in 1895.

The writer finds that the above is essentially the opinion of other geologists familiar with questions of this character. It is clearly stated in the following letter from one of the members of the International Commission on Stratigraphic classification: "I do not possibly see how the use of the term in the manner described could be regarded as a formation name. Many such indefinite uses of local names are found scattered everywhere through geological literature, and if we are to go back in every instance to such a usage, few I fear of our formation names would stand. The name to my mind must be applied to a definite series of deposits with clearly defined limits, if it is to have any formational significance."

near Topeka, to the Nebraska line.[1] The Burlingame limestone was named and described by Mr. Hall, in 1896, from outcrops near Burlingame, Kansas,[2] and since then, through the efforts of Professor Haworth and Messrs. Adams, Bennett, and Beede, its outcrop has been traced[3] from Nebraska across the state to Oklahoma. In its stratigraphic position this limestone is now regarded as forming the basal subdivision of the Wabaunsee formation, which is thus clearly marked, as the limestone forms a prominent escarpment along the greater part of the line of its outcrop across the state. The lower part of the Wabaunsee formation was described from exposures along Mill Creek and the Kansas River between McFarland and Topeka, its base being marked by the Silver Lake coal. At that time the Silver Lake coal, exposed in the Kansas River bluffs west of Topeka, was supposed to belong in the same horizon as the Osage coal and to form a zone capable of being traced for two thirds or more of the distance across the state.[4] Mr. Beede has shown later that the Topeka coal, 125 feet below the Silver Lake coal, is the Osage coal,[5] and since the higher coal is not conspicuous south of the Kansas River it does not serve as a continuous line of division for the base of the Wabaunsee formation. Along the Kansas River, however, the Burlingame limestone[6] is only from 15 to 35 feet above the Silver Lake coal, and as this limestone forms a marked outcrop extending entirely across the state, it serves as a definite line for the base of the Wabaunsee formation, as has been suggested by Professor Haworth.[7]

[1] Kans. Univ. Quar., Vol. VII, Series A, Oct., 1898, p. 232. A more detailed account will appear in Vol. XVI of the Transactions of the Kansas Academy of Science.

[2] Univ. Geol. Surv. Kans., Vol. I, p. 105.

[3] See "A map showing limestone outcroppings," by ERASMUS HAWORTH, Vol. III, Univ. Geol. Surv. Kans., 1898, Pl. VII.

[4] Jour. Geol., Vol. III, 1895, p. 689 and f. n. 1.

[5] Trans. Kans. Acad. Science, Vol. XV, 1898, p. 30.

[6] MR. BEEDE, in his paper on "The Stratigraphy of Shawnee County" used Swallow's name of Stanton limestone (*ibid*, p. 30).

[7] Univ. Geol. Surv. Kans., Vol. III, p. 105.

As already stated, Mr. Beede has traced the Burlingame limestone from near Topeka to the Nebraska line, where it is, apparently, exposed in the bluff on the northern side of the Great Nemaha River, nearly due north of Robinson, Kansas. At the base of the bluff, several feet below the limestone, coal has been mined which Mr. Beede thinks probably represents the Silver Lake coal, and his description of the stratigraphic position of other coal beds in northeastern Kansas strongly supports this correlation.[1]

On the Kansas River the Wabaunsee formation has a thickness of 500 feet, and this, apparently, agrees quite well with the thickness of the rocks included between the Burlingame limestone in southeastern Nebraska and the limestone west of Auburn, Nemaha county, which is considered to cap the formation and is correlated with the Cottonwood limestone. Mr. Beede states that it is but a short distance east of the exposure of Burlingame limestone and coal in the bluff of the Great Nemaha to the river's mouth, where Hayden saw the outcrop of coal and sandstone on the bank of the Missouri River.[2] This coal, according to Mr. Beede, "is without doubt the same coal that is mined on the north side of the Great Nemaha and, consequently, probably of the same horizon as the Silver Lake coal."[3]

This is an important correlation, for Meek was inclined to consider the outcrop at the mouth of the Great Nemaha as stratigraphically above the famous Nebraska City section, stating that: "I am inclined to believe this sandstone under the coal the same bed seen at Peru and Brownville, and at the base of the section at Aspinwall, though it may be another holding a lower position. If it is the same, there can be little doubt but the exposures here near Rulo hold a position in the series above the horizon of the Nebraska City section."[4] Mr. Beede has

[1] Kans. Univ. Quar., Vol. VII, p. 232, and the forthcoming Vol. XVI, Trans. Kans. Acad. Science.

[2] Final Rep. U. S. Geol. Surv. Nebraska and portions of Adjacent Territories, 1872, pp. 115 and 116.

[3] Trans. Kans. Acad. Science, Vol. XVI.

[4] Final Rep. U. S. Geol. Surv. Nebraska, etc., p. 116.

also studied the Nebraska City section and, although he has not traced the strata from the mouth of the Great Nemaha to that locality, still he says: "the rocks at Minersville [formerly Otoe City] and Nebraska City are just what we should expect if Meek's correlations were correct, as a comparison will show: At the base of the Nebraska City section are several layers of limestone, then, above, a thick bed of shales and sandstones, coal and limestone, then over 100 feet of shales which contain a second coal, and above this another limestone, which makes it agree in stratigraphic succession, as it does in fossils, with the Topeka section. Thus, considering the great care with which Meek did the work, we can but come to the conclusion that his correlation is probably correct.

"If the foregoing statements are correct, we are forced to the conclusion that the Nebraska City section of Meek, from the base of the lower limestone to the top of the Minersville section, corresponds to the Topeka section from the Topeka limestone nearly to the base of the Burlingame limestone."[1] While in another article, in discussing Meek's reference of the sandstone at the mouth of the Great Nemaha to a stratigraphic position above that of the Nebraska City section, he says: "If this be true, it throws the section at Nebraska City in the same general horizon with the Topeka-Osage coal, if it be not identical with it, and the limestone at the base of the section would then represent the Topeka limestone, or a part of it. While I have not been over the ground between Minersville and Rulo, Neb., I am of the opinion that this conclusion is correct."[2]

The writer is inclined to consider the conclusion of Mr. Beede regarding the age of the Nebraska City beds as correct; and if so the rocks composing this section are equivalent to the Topeka limestone and Osage shalesof the Kansas River section, which form the upper part of Professor Haworth's Shawnee formation of the Upper Coal Measures.[3] This correlation agrees

[1] Trans. Kans. Acad. Science, Vol. XVI.

[2] Kans. Univ. Quar., Vol. VII, Ser. A, pp. 232, 233.

[3] Univ. Geol. Surv. Kans. Vol. III. p. 94.

quite closely with my earlier one, for it was stated in that paper that: "The writer is not confident whether the Nebraska City beds should be referred to the upper part of the Missouri formation,[1] or to the Wabaunsee formation of the Missourian series. However, the faunal and lithologic characters of the beds near Nebraska City agree quite closely with those of the lower half of the Wabaunsee formation as shown along the Kansas River above Topeka, and so the writer refers them provisionally to it."[2]

The distribution of the carboniferous rocks in southeastern Nebraska has been given by Mr. N. H. Darton, on a "Preliminary Geologic Map of Nebraska,"[3] where they are represented under the legend of the "Cottonwood and Wabaunsee formations." On the same map, a part, at least, of the rocks mapped in the Big Blue valley as "Permian limestone" may be correlated with the Chase formation of Kansas.

It will be remembered that Marcou referred the Nebraska City beds to the Permian, and in this correlation he was supported by Geinitz, who described the fossils collected by Marcou, and strongly opposed by Meek, who referred the rocks to the Upper Coal Measures. This difference of opinion led to a sharp controversy, the essential features of which were noted in my former paper.[4] There is now no question but that Meek was correct in referring these rocks to the Coal Measures, as was noted in the writer's former paper, and is now stated by Mr. Beede.

It seems important, however, to again call attention to the fact that Meek in correlating these rocks along the Missouri River in southeastern Nebraska with the Upper Coal Measures

[1] At the time the above article was written I understood that Dr. Keyes intended to retain the above name for that division of the Missourian series next older than the Wabaunsee formation. It was not used, however, and now Professor Haworth's Shawnee formation includes that part of the series.

[2] JOUR. GEOL., Vol. V, p. 151.

[3] Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. IV, Pl. LXXXII.

[4] *Op. cit.*, pp. 12–16.

did not intend to include the rocks in Kansas which he and Hayden had called Permian,[1] a fact which has been overlooked by some of the later writers in considering the rocks of this region or the Permian. This was stated clearly enough by Meek when he gave his views regarding the age of these rocks as follows: "[they] really belong entirely to the true Coal Measures; unless the division C [the upper fossiliferous one] at Nebraska City, and some apparently higher beds below there on the Missouri, may possibly belong to the horizon of an intermediate series between the Permian and Carboniferous, for which, in Kansas, Dr. Hayden and the writer proposed the name Permo-Carboniferous . . . . . It is true that in first announcing the existence of Permian rocks in Kansas, we also, upon the evidence of a few fossils from near Otoe and Nebraska Cities, resembling Permian forms, referred these beds to the Permian; but on afterwards finding that these fossils are there directly associated with a great preponderance of unquestionable Carboniferous species; and that there is also in Kansas a considerable thickness of rocks between the Permian and upper Coal Measures containing, along with comparatively few Permian types, numerous unmistakable Carboniferous forms, we abandoned the idea of including these Otoe and Nebraska City beds in the Permian. And all subsequent investigations have but served to convince us of the accuracy of the latter conclusion."[2] This view was explained more fully in Meek's Review of Geinitz, on the rocks and fossils of Nebraska, published in the November following his exploration there, in which, after describing a series of rocks occurring in Kansas, containing an extensive Coal Measure fauna, often mingled in the same beds with a few Permian types, he said: "In ascending several hundred feet higher in the series, we observed the Coal Measure forms gradually dropping off until at last, above a certain undefined horizon, with the exception of one or two of the latter,

[1] Trans. Albany Inst., Vol. IV, 1858, p. 76; Proc. Acad. Sci. Phil., Vol. XI, 1859, pp. 20. 21; and Am. Jour. Sci., 2d ser., Vol. XLIV, 1867, p. 37.

[2] Final Rep. U. S. Geol. Surv. Neb. etc., pp. 130, 131.

only Permian forms were observed. Although we regarded these upper beds as the true representatives of the Permian, we gave a section of the whole series, down so as to include a considerable thickness of beds below, with lists of fossils, showing the range of the various types, without drawing any line of demarkation, because we were satisfied nature had nowhere defined any abrupt physical or paleontological break here in the series,"[1] . . . . that is, that there is in this region [Kansas], a gradual shading off from an upper Coal Measure to a Permian fauna, through a considerable thickness of strata, forming a somewhat intermediate group, which we called the Permo-Carboniferous series; also that there is no defined break between this intermediate series and the Permian above, or the Coal Measures below."[2]

It is also true that Hayden did not abandon the correlation of the highest Paleozoic rocks of Kansas with the Permian, for in July, 1867, he published some "Notes on the Geology of Kansas," in which he reviewed "Swallow's Preliminary Report of the Geological Survey of Kansas," not accepting his division of the Lower Permian as of true Permian age, and said: "As we ascend in the series, we find that, after going some distance above the supposed line of demarcation [Swallow's between the Lower Permian and Coal Measures] the Carboniferous species gradually begin to disappear, and the Permian types become rather more common, in particular beds, until we have ascended to a point near the horizon Professor Swallow makes the line between the Upper and Lower Permian, when we find we have almost completely lost sight of the familiar Carboniferous species, a few of which had continued on up to near this point, and see scarcely any but forms such as in Europe would be regarded as Permian types. There is no physical break here, however, nor *abrupt* change of fossils. Hence Meek and Hayden regarded the beds below the horizon down so far as to include most, if not nearly all, of Professor Swallow's Lower

[1] Am. Jour. Sci. 2d ser. Vol. XLIV, 1867, p. 334.

[2] *Ibid*, pp. 338–339.

Permian, as an intermediate connecting series between the Permian and Coal Measures which, if worthy of a distinct name at all from the latter, should be called Permo-Carboniferous, while the beds above they regarded alone as properly the equivalent of the true Permian of Europe.

The occurrence of a few types that would generally be regarded as Permian, along with numerous well-known Coal Measure species, far below the true Permian, only accords with facts observed in other formations in this country, where certain types evidently made their appearance here long before they are known to have appeared in Europe."[1] In discussing the rocks of Gage county, Nebraska, in the Final Report of 1872, Hayden also described a section on a small branch of the Big Blue River, near Beatrice, about which he wrote as follows: "Beds 1, 2, and 3 of the above section are undoubtedly of Permian or Permo-Carboniferous age, though they contain fossils common to both Permian and Carboniferous rocks. . . . . Bed 4 seems to form a sort of transition bed between the Permian[2] and Carboniferous [misprint for Cretaceous] formations."[3]

This later study of the rocks of southeastern Nebraska has made it possible for us to determine approximately how far below the base of Meek and Hayden's Kansas Permian the Nebraska City rocks occur, and this is perhaps its most important result. The line between the Permian and Permo-Carboniferous of Meek and Hayden was drawn at the top of No. 11 of their "General section of the rocks of [the] Kansas Valley;"[4] which, as I have shown, occurs about ninety feet below the top of the Chase formation.[5] Then, if we accept the correlation that

[1] *Ibid.*, p. 37. In this paper Hayden referred to notes which Meek had given him, stating that they "form the substance of this article," p. 321.

[2] It is not certain that the true Permian beds, as recognized in Kansas, extend northward into Nebraska, though thin beds may occur in some of the southern counties.

[3] Final Rep. U. S. Geol. Surv. Nebraska, etc., p. 28.

[4] Proc. Acad. Nat. Sci. Phil., Vol. XI, 1859, pp. 16 and 20.

[5] Jour. Geol., Vol. III, pp. 784, 797, 798.

the top of the Minersville-Nebraska City section is stratigraphically a little lower than the Burlingame limestone, we will find that on the Kansas River, between the base of this limestone and that of Meek and Hayden's Permian are the Wabaunsee, Cottonwood, and Neosho formations, together with the greater part of the Chase formation, having a total thickness of approximately 900 feet. When it is also considered that massive limestones constitute a considerable portion of these rocks it will be seen that there is a decided time interval between the Nebraska City rocks and those of Meek and Hayden's Permian in Kansas. Or, again, the thickness of the rocks between the base of the Burlingame limestone and the base of Swallow's Lower Permian along the Kansas River, or Meek and Hayden's Permo-Carboniferous, is approximately 525 feet.

The failure to note the difference in age and faunas between the rocks of the Nebraska City region, along the Missouri River, and those of the upper Kansas and lower Smoky Hill River valleys in Kansas has led to certain erroneous statements and conclusions. This is possibly the explanation for the statement of Professor Calvin in his contribution to "A symposium on the classification and nomenclature of geologic time-divisions," in which he says: "The greater part of the assemblage of strata called Permian by Prosser and the geologists of Kansas University contains precisely the same fauna as our Missourian or Upper Coal Measures, and if there is no better excuse for recognizing Permian in America than that afforded by the beds in question, then America has no Permian."[1] The rocks which I have correlated as Permian, but without expressing a positive opinion as to whether the division should rank as a distinct system or as the upper group of the Carboniferous system (using Dana's stratigraphic terms) are the Neosho, Chase, Marion, and Wellington formations and the Cimarron group or Red-beds. The line between the Permian and the Upper Coal Measures or Missourian group was drawn provisionally at the base of the Neosho formation;[2] because in the Neosho and

[1] JOUR. GEOL., Vol. VI, p. 353.

[2] *Ibid.*, Vol. III, pp. 795, 800.

Chase formations zones occur in which there are numerous specimens of a few species which belong to genera that in Europe are regarded as of Permian age; but inter-stratified with these zones are others which contain numerous specimens of a considerable number of the Missourian species. The writer has already stated that "The Neosho and Chase formations are transitional from the Upper Coal Measures to the Permian as first defined by Murchison for Russia, and belong to the division which has generally been called Permo-Carboniferous in this country. In accordance with the views of the majority of present European geologists familiar with this problem it is probably better to include the Permo-Carboniferous rocks of Kansas in the Permian series."[1] The base of the Neosho formation is about 50 feet higher than the base of Swallow's Lower Permian or Meek and Hayden's Permo-Carboniferous; and the top of the Chase formation is, approximately, 90 feet higher than the base of Meek and Hayden's Permian, or between 50 and 80 feet lower than the top of Swallow's Lower Permian. The thickness of the Neosho is 130 feet,[2] and that of the Chase 265 feet,[3] making a total thickness of 395 feet. Mr. Beede, who is describing the Carboniferous and Permian invertebrate faunas for the University Geological Survey of Kansas, writes me that "there is ample evidence for placing the division line between the Coal Measures and Permian where you have."

Succeeding the Chase is the Marion formation, with a thickness of from 300 to 400 feet.[4] The lower portion of the Marion contains a fair Lamellibranch fauna which, however, decreases until in its upper part very few species are found. The following thirteen species and one variety have been found in this formation, together with some other forms which as yet have only been doubtfully identified either specifically or generically, viz.: *Aviculopecten occidentalis* (Shum.) Meek, *Bakevellia parva* M. &

[1] Jour. Geol., Vol. III, pp. 795, 796.

[2] *Ibid.*, pp. 766, 799.

[3] *Ibid.*, pp. 773, 798.

[4] Univ. Geol. Surv. Kans., Vol. II, p. 66.

H., *Myalina perattenuata* M. & H., *M. permiana* (Swallow) M. & H., *Nautilus eccentricus* M. & H., *Nuculana bellistriata* Stevens var. *attenuata* Meek, *Pleurophorus Calhouni* M. & H., *P. subcostatus* M. & W., *P. subcuneatus* M. & H., *Pseudomonotis Hawni* (M. & H.) sp., *P. Hawni* (M. & H.) sp. var. *ovata* M. & H., *Schizodus curtus* M. & W., *S. ovatus* M. & H., and *Yoldia subscitula* M. & H.

All of the species are Lamellibranchs with the exception of the *Nautilus* which is a Cephalopod. One species begins in the Lower Coal Measures; another is first reported from the Des Moines of Iowa and then from the Kansas Permian, not appearing in the interval; six appear in the Upper Coal Measures and the remaining six are known only in rocks of the age of Meek and Hayden's Kansas Permian, with one exception, which is reported from the Permo-Carboniferous of Utah and from rocks in New Mexico referred doubtfully to the Upper Coal Measures.

The abundant species and about the only ones found in the upper part of the formation are:

1. *Bakevellia parva* M. & H. — Permian of Kansas (in each instance meaning that division of Meek and Hayden), and from Arizona in rocks stated by Dr. White to probably belong in the Permian, while he found a closely related form in New Mexico "at the summit of the Carboniferous series" (U. S. Geog. Surv. W. 100 Merid., Vol. IV, p. 153). This species is closely related to *B. antiqua* Münster, which is common in the Permian of England, Germany, and Russia.

2. *Myalina permiana* (Swallow) M. & H. — Permian of Kansas and Texas. Reported by Hall & Whitfield from the Permo-Carboniferous of Utah; and by Dr. White from New Mexico in rocks which were referred doubtfully to the Upper Coal Measures.

3. *Pleurophorus subcuneatus* M. & H. — Permian of Kansas; Dr. Keyes reports: "There is but little doubt that the form from Des Moines [Lower Coal Measure of Iowa] is identical with that figured by Geinitz in 1866 as *Pleurophorus simplus* of Keyserling" (Proc. Acad. Nat. Sci., Phil., 1891, p. 250). There is no other record, however, of the occurrence of this species until Meek and Hayden's Permian is reached in Kansas, and Mr. Beede informs me that he has not seen it below the Permian there. This species is so nearly related to the *P. simplus* v. Keys. sp. of the Russian Permian that Geinitz regarded them as identical.

4. *Pseudomonotis Hawni* (M. & H.) sp. — Permian of Kansas. Heilprin

reported from the Upper Coal Measures of Pennsylvania "an obscure impression which may be that of this species, but very doubtful" (Second Geol. Surv. Pa., Ann. Rep., 1885, p. 455). Mr. Beede writes me, however, that it begins near the base of the Upper Coal Measures of Kansas, and he will shortly publish an article describing the Kansas species of this genus. This species was regarded by Swallow and Geinitz as identical with *P. speluncaria* Schloth. sp., which is a common Permian form in England and Germany.

5. *Myalina perattenuata* M. & H. also occurs near the top of the Marion and is reported from the Permian of Kansas and Texas, and the Upper Coal Measures of Missouri and Illinois.

The only Brachiopods found are specimens of *Derbya* from the lower part of the formation, which are doubtfully referred to the species *D. multistriata* M. & H. sp., which occurs in their Kansas Permo-Carboniferous. The disappearance of the Brachiopods was perhaps due in part to the diminished depth of the water, but in a much greater degree, undoubtedly, to the highly concentrated nature of the waters, as shown by the deposits of rock salt and gypsum. This change in the condition of the water affected the other forms of life unfavorably; but there remained, as we have seen, a meager Lamellibranch fauna which differed decidedly from the Lamellibranch fauna of the Coal Measures and is closely allied with the Permian Lamellibranch fauna of Europe.

The Wellington formation succeeds the Marion, varying in thickness from about 200 feet on the Smoky Hill River to 450 feet in Sumner county, near the southern line of the state,[1] in which, as far as known to the writer, no fossils have yet been found.

The Paleozoic of Kansas closes with the Cimarron group or the Red-beds, which in the southern part of the state are from 1150 to 1400 feet thick.[2] The absence of fossils has formerly made the correlation of this group rather indefinite. Professor Cragin has compared the stratigraphy of the Red-beds of the Kansas-Oklahoma basin with those of northern Texas and stated

[1] Univ. Geol. Surv. Kans., Vol. II, p. 67.

[2] *Ibid.*, p. 88.

that the gypsum beds of the Cave Creek formation, the top of which is about 250 feet below the summit of the Kansas Red-beds, apparently connect them "by a bond of stratigraphic continuity with the demonstrated Permian of Texas."[1]

Fossils have recently been found about 100 feet above the base of the Cimarron group in the northern part of Oklahoma. The most abundant specimens are species of a Phyllopod Crustacean which unfortunately were poorly preserved and, therefore, identified with some doubt by Professor T. Rupert Jones as *Estheria minuta* Alberti sp.[2] This species is characteristic of the Triassic in England, France, and Germany, apparently occurring most abundantly in the Keuper of the Upper Triassic.

Associated with the Crustacean fossils was the greater part of the skeleton of an Amphibian which has been identified by Professor Williston "as *Eryops megacephalus* Cope, a form described from the 'Permian' of Texas." Professor Williston, in discussing the importance of this discovery in reference to the age of the Red-beds, says: "This identification settles once for all the horizon whence it came as Permian, if the Texas beds be really of that age. There are several hundred feet of deposits in Kansas above this horizon that still possibly may be considered as Triassic, but there is no reason for so doing. *Estheria minuta* is a Triassic species, but, even if correctly determined, its value is slight in comparison with that of the vertebrate in the correlation of the beds. It must be remembered, however, that *Eryops* is by no means necessarily characteristic of the Permian."[3]

Professor Williston has written me as follows regarding Cope's correlation of the Texas deposits with the Permian: "In his first work upon the Texas beds Cope determined them as Triassic, and he seems never wholly to have overcome the idea

[1] Colorado College Studies, Vol. VI, p. 5; see also pp. 2, 3, 30, 48. The correlation of the Red-beds from this stratigraphic evidence was discussed by the writer in the Univ. Geol. Surv. Kans., Vol. II, pp. 89–92.

[2] Geol. Mag., Dec. IV, 1898, Vol. V, p. 292.

[3] Science, N. S., Vol. IX, Feb. 10, 1899, p. 221.

that they may not be of Triassic age, but in all his later papers upon the forms he refers to the beds as Permian. I suppose the reason for this collocation is the fact that the nearest related forms are found in the European Permian. Thus, *Euchirosaurus* and *Actinodon* are referred to the lower Permian in France (the Rothliegenden of Autun). I at first thought that the present form might be *Actinodon*, but the bones made out agree quite closely with the figures of *Eryops megacephalus* given by Cope."[1]

The above brief summary of the Permian rocks of Kansas shows that fossils occur in beds varying in thickness from 1000 to 1350 feet; while if all of the Red-beds are of the same general age, as is possible, the estimated total thickness of the Permian would then range from 2050 to 2650 feet. The majority of the species found in the lower 400 feet, the Permo-Carboniferous deposits, occur in the Upper Coal Measures (Missourian), and perhaps one half of the species in the succeeding 300 or 400 feet; but above that horizon none have been found which are even closely related to those in the Coal Measures. On the contrary, this higher fauna seems to be as nearly related to the Triassic as to the Carboniferous. This would seem to be sufficient proof that the greater part of Permian strata does not contain "precisely the same fauna as our Missourian or Upper Coal Measures," since only the lower 400 feet of deposits, ranging in thickness from 1350 to perhaps 2650 feet, contain a fauna composed largely of species which occur in the Upper Coal Measures. These lower beds are transitional, but this fact does not seem to the writer to furnish sufficient proof that the higher ones at least are not of Permian age.

CHARLES S. PROSSER.

UNION COLLEGE,
March 1899.

[1] Letter of Feb. 26, 1899.

THE NEBRASKA PERMIAN[1]

WHETHER or not true Permian rocks occur in Nebraska has been an open question for many years. Nevertheless, it has been customary for geologists mapping southeastern Nebraska to assign to it a narrow belt of territory extending from a point on the Nebraska-Kansas line sixty miles west of the Missouri River, north and east to Omaha. So far as the literature on the subject goes, there is absolutely no data that would warrant this construction. Probably these maps have been constructed upon the supposition that, since Permian rocks were known in Kansas, they might extend northward into Nebraska, and in case they did they would be found between the Carboniferous Coal Measures and the Dakota sandstone of the Cretaceous.

Professor Marcou[2] was the first geologist to suggest the occurrence of Permian rocks in Nebraska. Prior to that time the Paleozoic escarpments along the Missouri River had been considered Carboniferous by both Nicollet[3] and Owen.[4] In studying this region Professor Marcou made a very thorough examination, and it was his candid opinion that the rocks were

[1] In 1885, while a student in the University of Nebraska, the question of the occurrence of the Permian rocks in Nebraska came up in class and was thoroughly discussed, some maintaining the statements of Marcou, others those of Meek. The result was anything but satisfactory, and Dr. Hicks suggested to me that it would be a good plan to investigate the Paleozoic rocks of Nebraska and determine, if possible, whether there were any rocks that could be assigned to the Permian. This was carried out. The Missouri River, Platte River, Cass, Otoe, Richardson, Johnson, and Pawnee counties were visited, and Meek's conclusions that these rocks were Coal Measures confirmed. Still believing that the Permian rocks might occur in the southern portion of the state, work was resumed in Gage county. The data collected at that time are here presented in their original form, except that there are numerous references to Prosser's papers.

[2] Bull. Soc. Geol. France, 2 ser., Jan. 1864, Vol. XXI, pp. 134–137.

[3] NICOLLET'S map.

[4] Report of the Geol. Surv. of Wis., Iowa, and Minn., and incidentally of a portion of Nebraska Territory, pp. 133–135.

Dyas (Permian). Later Professor Geinitz,[1] of Dresden, studied the fossils collected by Professor Marcou, and in an article confirmed Marcou's classification. The work of Marcou and Geinitz called forth some severe criticism from American geologists, which culminated in Professor Meek's masterly production in the Final Report of the U. S. Geological Survey of Nebraska, in which he proved conclusively that the Missouri River rocks extending from the mouth of the Platte River, southward along the Missouri River in Nebraska, were Coal Measures. The only recent publication bearing on the subject of the Missouri River rocks in Nebraska is an article published by Professor Prosser,[2] in which he strongly supports Meek's views. Without question these rocks must be considered Coal Measures.

Early investigators paid little or no attention to the Paleozoic exposures lying some distance west of the Missouri River. While making his reconnaissance for the final report on the geology of Nebraska, Dr. Hayden suggested that the true Permian rocks as found in Kansas might occur in some of the southern counties of Nebraska. However, his statements are very confusing and assure one that he had not arrived at any definite conclusion. While suggesting in a footnote[3] that the Kansas rocks might extend northward into Nebraska, on the same page, in discussing the Beatrice section, he says: "Beds 1, 2, and 3 of the above section are undoubtedly Permian or Permo-carboniferous, though they contain fossils common in both Permian and Carboniferous rocks. . . . . Bed 4 seems to form a sort of a transition bed between Permian and Carboniferous formations. The Permian rocks pass beneath water level at Beatrice westward," etc. The fossils on which the above statements in reference to the Beatrice section were made were *Syntrilasma* (*Enteletes*) *hemiplicata* and *Pinna peracuta*. Dr. Hayden visited many outcrops within the Permian area in Gage

[1] M. d. K. Leop. Carol. Acad. d. Naturl. Carbonformation und Dyas in Nebraska. Dresden, pp. vii + 91. 5 plates.

[2] Jour. Geol., Vol. V, No. 1, pp. 1–16, and No. 2, pp. 148–172.

[3] U. S. Geol. Surv. of Nebraska, final report, p. 28.

county while making his survey. In his report he mentions the bands of cherty limestone so characteristic of the Kansas beds and many other features that could only lead one to correlate these formations. Unfortunately, it has been found impossible to identify Dr. Hayden's sections along the Big Blue River. The reasons for this are apparent when it is known that he speaks of the bluffs at Blue Springs as being from ten to fifteen feet high, when in reality they vary from fifty to ninety above the river. Since Dr. Hayden's report nothing of importance was published pertaining to these rocks until 1886, when L. E. Hicks,[1] then Professor of Geology in the University of Nebraska, published two short papers. These articles were so general in character that it was impossible for any one to arrive at any definite conclusion regarding the area under discussion. In 1897 Prosser published two articles in which he discussed and reviewed the work of previous writers on the Paleozoic of Nebraska, and compared the Missouri River rocks with the Kansas beds. In the first of these articles[2] Prosser refers briefly to the exposures along the Big Blue River, and concludes by saying: "These rocks are undoubtedly of Permian age, and it is probable that the Neosho formation, and possibly a part of the Chase, occurs in Gage county."

Since the discovery of Permian rocks in Kansas by Swallow[3] there has been a considerable time devoted to their study by numerous geologists. The stratigraphical features are well known and the fauna has been carefully studied, although there is much to be accomplished in a more exhaustive study of the fossil life. Recently Prosser[4] has brought together all of the

[1] Transactions A. A. A. S., Buffalo meeting, 1886, and the American Naturalist, Oct. 1886, pp. 882, 883. The data embodied in these two articles were taken from my notes.

[2] JOUR. GEOL., Vol. V, p. 12.

[3] See Trans. Acad. Sci. St. Louis, Vol. I, pp. 111, 112.

[4] See Bull. Geol. Soc. Am., Vol. VI, pp. 29–54; JOUR. GEOL., Vol. III, 1895, pp. 682–705 and 764–800; University Geol. Surv. of Kansas, Vol. II, pp. 55–96. See also an article by PROFESSOR HAWORTH in the University Geol. Surv. of Kansas, Vol. I, pp. 185–194.

history bearing on these rocks, and added much valuable information to the literature by a careful examination of the many exposures. His classification must stand as a basis for correlating the Permian rocks of the central western United States.

The Nebraska Permian is the northern extension of Kansas beds, and agrees with them in all of the essential characters. The area is of a flatiron shape, with the broad end to the south resting upon the Kansas-Nebraska line. The northern limit is probably in the vicinity of Roca, Lancaster county. On the east the boundary has only been approximated, since the highlands separating the valley of the Nemaha from the valley of the Big Blue River, are so deeply buried with loess that there are few, if any, rock exposures. Typical Permian rocks were found near the eastern line of Gage county, and Coal Measures near Pawnee City, Pawnee county. From these data it is supposed that the eastern boundary of the Permian extends from Roca south and east into Johnson county, thence southward through the western end of Pawnee county into Kansas. The western boundary, from Roca to Beatrice, is also buried beneath a very thick bed of loess; but from Beatrice southward it was traced with considerable accuracy, since there were numerous outcrops of both Permian and Dakota sandstone. Only a short distance west of Beatrice the Dakota sandstone crosses the river and trends south and east along the southwestern border of the valley of the Big Blue River to a point known as "The Mounds," which is a high bluff capped by Dakota sandstone on the west bank of the river some two miles west of Holmesville. From this bluff, the highest in this section of the country, the boundary trends south and west, passing several miles west of Blue Springs, thence westward along the north side of Indian Creek to a point about two miles west of Odell, where it crosses the creek and turns eastward and follows the south side of the valley of Indian Creek nearly to the Big Blue River, where it bends southward and keeps a southern course to the Kansas line. As bounded, this area, comprising nearly five hundred square miles, is nearly confined to Gage county, and, with the exception of that portion in

Lancaster county, is drained by the Big Blue River and its tributaries. This river enters the central western border of the Permian field and flows eastward and southward through the western half into Kansas. All of its tributaries in the Permian rocks are small streams and of little importance.

The topography of this region is wholly unlike that of any other part of the state. There are highlands of almost level prairie, which change gradually into rolling prairie, and in some localities the rolling prairie shades into rough and broken country that is only fitted for pasture land. As the tributaries approach the river they usually flow through narrow, deep ravines or gulches, and in numerous places there are miniature canyons with precipitous walls of cherty limestone. The Big Blue River flows through a gradually narrowing valley. At Beatrice the bluffs are low and well rounded and the valley quite wide. In the vicinity of Holmesville, the bluffs are very much higher and steeper, and near the Kansas line they are from fifty to one hundred and fifty feet high and in many places very precipitous. Where the exposures approach the perpendicular the walls are usually cherty limestone. The chert, which is almost black, occurs in regular bands of varying thicknesses. These exposures, when viewed from a distance, with their alternating layers of light and dark stone, partly vine-clad, remind one of the work of man rather than nature; and it does not require a vivid imagination for one to see ruin after ruin as the eye wanders down the river; here an old fortress, there an old church, and in the distance the rude outline of an old crumbling castle. This rugged scenery, mingled with the many groves and the winding river, makes this one of the most picturesque localities of the state. The elevation of this region above the sea varies from 1150 feet, at the state line, to about 1300 feet, on the divide between Roca and Beatrice. Judging from the deposits of drift along the river, the Permian has undergone glaciation. There are a few V-shaped troughs, varying in depth from two to five feet, and these are usually filled with granite and quartzite pebbles and sand. The Big Blue River was very near the southwestern limit of the great

ice sheet. North and east of Holmesville there are a few isolated patches of Dakota sandstone that have escaped glaciation.

In studying the Permian, work was commenced at Roca, but on account of the slight exposure and the scarcity of fossils, no detailed examination was made. A few specimens of *Enteletes hemiplicata* (Hall) were all the fossils seen, and the vertical range of this species is too great to allow it as evidence for or against the Permian. In the vicinity of Beatrice, only two slight exposures of yellowish shelly limestone were found. One of these was just below the dam, on the east bank of the river, and the other on the west side of the river in a ravine about a half mile southwest of the upper bridge. These rocks[1] were barren of fossils. By following the Union Pacific railroad down the river about a mile below town, a slight exposure of very poor limestone was found in a cut. From this point southward the limestone surface along the bluffs gradually rises above the railroad grade which follows the course of the valley. Three miles below Beatrice at the old cement mill, the following section was taken:

No. 4. Soil and drift - - - - - - -	4 feet
No. 3. Yellowish shelly limestone - - - - -	4 feet
No. 2. Cellular light gray limestone - - - -	13 feet
No. 1. Bluish hydraulic limestone - - - - -	8 feet
Total, - - - - - - - - -	29 feet

No. 1 of this section was utilized during the seventies for manufacturing hydraulic cement. Nos. 1 and 2 contained the following fossils:

Productus semireticulatus Martin.
Ambocelia planoconvexa Shum.
Meekella striatioconstata Cox.
Seminula argentea Shep.
Bellerophon sp.

From the old cement mill down along the river on the east bank there are numerous exposures of the above section. At "The Mounds" the Permian is capped with about forty feet of brown Dakota sandstone, and the junction of the two formations

[1] DR. HAYDEN reports two species. See final report of the U. S. Geol. Surv. of Nebraska, p. 28.

is entirely obliterated with soil and débris. Numerous slight exposures of Permian rocks were found that were above the cement mill section and with them *Seminula argentēa* (Shep.) but no other fossil.

At Holmesville there were numerous exposures and many of them had been opened as quarries. To the north of the depot there is a quarry face over a quarter of a mile in length and averaging twenty feet in height. The limestones of this quarry are all thick bedded and one band has a peculiar habit of changing in color from a bluish to a cream color within a distance of twenty feet. South of the bridge there is a thin bed of oölite that thickens rapidly toward the south. It is very fossiliferous, but thins out before reaching the quarries north of the depot, where the following section was made:

No. 5. Soil, sand and drift	9 feet
No. 4. Yellowish to bluish limestone with geodes filled with quartz crystals, in some places cellular and containing fossils	10½ feet
No. 3. Bluish limestone	4 feet
No. 2. Cherty limestone	6 feet
No. 1. Unexposed to the river	14 feet
Total	43½ feet

The oölite has not been included in this section but belongs between Nos. 3 and 4, which are quarried for building purposes. The following fossils were taken from the oölite and No. 4.

Productus semireticulatus Martin.
Meekella striatiocostata Cox.
Aviculopecten occidentalis Shum.
Aviculopecten sp.
Aviculopecten sp.
Schizodus ovatus M. and H.
Schizodus wheeleri Swal.
Schizodus sp.
Yoldia subscitula M. and H.
Bakevellia parva M. and H.
Edmondia sp.
Edmondia sp.
Loxonema sp.

Pleurotomaria sp.
Murchisonia nebrascensis Gein.
Bellerophon montfortanus N. and P.
Naticopsis cf. *remex* White.

Southwest of Holmesville two and a half miles, on the west bank of the river, there is a long escarpment of very excellent limestone, that in early days was quarried and transported by wagons as far as Lincoln, to be used for building purposes. It occurs in good workable beds and breaks across the bedding as well as with it. When the stone is taken from the quarry it is easily cut with saw or plain, but upon exposure it becomes very much harder. When large dry blocks are struck with a hammer they have a metallic ring. It has been called magnesian limestone, and resembles very much the so-called magnesian limestones, that have been quarried from the Kansas Permian for many years.

SECTION OF QUARRY

No. 6.	Cream colored limestone	⅛ foot
No. 5.	" " "	2½ feet
No. 4.	" " "	3⅓ feet
No. 3.	" " "	3 feet
No. 2.	" " "	3 feet
No. 1.	Bluish and gray limestone	8 feet
	Total	20⅔ feet

The position of this section in reference to Holmesville is questionable. Levels were not run but there is some evidence that it occupies a place lower than the Holmesville bed. Possibly it may represent the Holmesville section in part; the differences in the strata being accounted for by a difference in sedimentation. Only a few fossils were found.

Aviculopecten occidentalis Shum.
Sedgwickia alteristriata? M. and H.
Myalina aviculoides M. and H.
Derbya robusta Hall.
Edmondia sp.
Pleurophorus sp.
Slight impressions of *Nautilus* or *Metacoceras* and a large pelecypod.

The next examination was made at Blue Springs. The bluffs opposite the town are from fifty to ninety feet above the river bed and extend down the stream for two or three miles. The most striking feature of these bluffs is the thick bed of cherty limestone that has not been seen to the northward, but which may yet be found at "The Mounds," or along some of the highlands away from the river. Below the cherty band along the bluffs, the slopes are in many places paved with large blocks of cherty limestone that have been loosened by frost. Above the cherty layer, there are several bands of workable limestone that have been quarried for building purposes. While the Blue Springs exposure is above the Holmesville, it is not definitely known what it rests upon. It is quite possible that there is a series of rocks intervening that have not been discovered.

BLUE SPRINGS SECTION

No. 10.	Soil	2 feet
No. 9.	Yellow shelly limestone	5½ feet
No. 8.	Compact yellowish limestone containing vertebrates and many invertebrates	7½ feet
No. 7.	Cherty limestone, fossiliferous	1½ feet
No. 6.	Yellowish soft limestone	1⅔ feet
No. 5.	Cherty limestone, fossils in chert	16 feet
No. 4.	Indurated and variegated marls	20 feet
No. 3.	Bluish limestone	10 feet
No. 2.	Unexposed	10 feet
No. 1.	Bluish limestone	3 feet
	Total	69⅔ feet

Nos. 7 and 8 contain a great many fossils, some of which are new to science. The following were collected:

Productus semireticulatus Shum.
Meekella striatiocostata Cox.
Orthis sp.
Seminula argentea Shep.
Aviculopecten occidentalis Shum.
Aviculopecten maccoyi M. and H.
Aviculopecten sp.
Orbiculoidea sp.

Orbiculoidea sp.
Bellerophon sp.
Myalina permiana? Swal.
Rhombopora lepidodendroides? Meek.
Myalina aviculoides M. and H.
Dentalium sp.
Derbya crassa M. and H.
Derbya robusta Hall.
Strapharollus subrugosus M. and H.
Archeocideris sp.
Fenestella sp.
Polypora sp.
Fistulipora sp.
? ? Ceromya sp. probably a new genus of pelecypods.
Vertebrates:
Styptobasis knightiana Cope.
Diplodus sp. nov.

Professor Cope[1] in describing Styptobasis as a new genus remarked: "This was a large shark of carnivorous habits, and its presence indicates the existence of a marine fauna whose remains have not been discovered." Associated with No. 8 was a huge Pinna nearly three feet long.

Quarries and exposures were also examined in the vicinity of Wymore, but no additional data were secured, since the sections were the same as at Blue Springs.

At Odell several slight exposures were found along the bluffs, and one in a small gulch west of the town. From the last one mentioned a single specimen of *Chænomya minnehaha* (Swal.) was taken. On account of the exposures being slight, and no chance to study more than a few feet of limestone, the Odell region was not worked over. From a few measurements of rock in place the dip was found to be slightly to the southwest.

The exposures along the river south from Wymore, are very numerous and in many places form continuous bluffs, but none of these were critically examined until the Kansas-Nebraska line was reached. Here there were the finest exposures seen along

[1] See COPE's description, Proceedings of the U. S. Nat. Museum, Vol. XIV, pp. 447, 448.

the river, and they were also quite accessible for study. The cherty band as seen at Blue Springs can be seen on every bluff, and the limestones above resemble the stone quarried at the Blue Springs quarries. But above all of these bands, there are several that have not been seen to the north. The following section was made at the state line.

No. 7.	Yellowish oölitic limestone - - -	8½ feet
No. 6.	Light colored limestone, shelly - - -	4 feet
No. 5.	Yellowish limestone - - - -	8 feet
No. 4.	Light colored limestone with some chert -	13 feet
No. 3.	Very cherty limestone - - - -	15 feet
No. 2.	Indurated marls, variegated - - -	15 feet
No. 1.	Unexposed to the river - - - -	20 feet
	Total - - - - - - - -	73½ feet

No fossils were found below the cherty bands. Nos. 5, 6, and 7 contained a great many fossils, No. 7 being especially rich in species as well as in numbers. The following is a partial list. Many of the fossils were so frail that by the time they had been packed, shipped, and unpacked no one could identify them,

Nautilus eccentricus M. and H.
Metacoceras dubium Hyatt.
Metacoceras sp.
Myalina aviculoides M. and H.
Myalina perattenuata M. and H.
Myalina permiana Swal.
Myalina sp.
Seminula argentea Shep.
Pseudomonotis hawni M. and H.
Pseudomonotis hawni ovata M. and H.
Pseudomonotis sp.
Meekella striaticostata Cox.
Derbya crassa M. and H.
Derbya robusta Hall.
Aviculopecten occidentalis Schum.
Aviculopecten sp.
Bakevellia parva M. and H.
Pinna sp.
Yoldia subscitula M. and H.
Schizodus sp.

Schizodus sp.
Solenomya sp.
Solenomya sp.
Fenestella sp.
Pleurophorus sp.
Edmondia sp.
Scaldia sp. nov.
Allorisma subcuneata M. and H.
Allorisma cf. *elegans* King.
Chaenomya laevenworthensis M. and H.
Bellerophon marcouanus Gein.
Bellerophon sp.
Avicula cf. *lanceolata.*
Orthoceras sp.

At Oketo, Kan., two miles south of the state line, there are large quarries worked in the bands above the cherty limestone. The exposures along the bluffs at Oketo were the same as seen at the state line, except there were a few new bands above the oölitic limestone. The cherty limestone band that has been traced from Blue Springs to the state line and on to Oketo is, beyond question, the same band that outcrops to the north of Marysville, Kan., and that it is the Florence[1] flint of Prosser's Chase formation. If this correlation is correct, the cherty limestone that is only partly exposed at Holmesville will equal the Strong flint of Prosser's Kansas section, in which case the Chase formation would extend as far north as Beatrice, and the Neosho from Beatrice to Roca. There are some stratigraphical differences noted while comparing the formations of the two states, but this will undoubtedly disappear with more detailed study. The most marked is the occurrence of oölites in Nebraska that have not been reported from Kansas. Prosser calls the variegated band underlying the Florence flint a shale, while the same band in Nebraska is an indurated marl. At all exposures attempts were made to take the dip, but as a rule the readings were anything but satisfactory. At Holmesville and Blue Springs there were places, which appeared to be caused by warping, where

[1] See PROSSER'S conclusion as to the Marshall county, Kansas rocks, Vol. V, JOUR. GEOL., p. 12.

the strata dipped slightly to the east, but in the same quarries one could find slight dips in almost any direction. By comparing the height of the base of the Florence flint with the railroad grade at Blue Springs and Oketo, it was found that these rocks had a southern dip of five feet to the mile. This information, coupled with the readings taken at Odell, makes it very certain that these rocks dip to the southwest.

In comparing the fossil life of the two states there are greater differences than one might expect, especially when the Upper Permian rocks are not known to Nebraska. So far there are many more lingering Coal Measure species reported from Kansas than Nebraska. As soon as the questionable species of both states have been classified, the greatest differences in the fauna will disappear. There is another interesting point that is not out of place here. There are a few species of invertebrates reported from the Texas Permian that are common to the Permian of Kansas and Nebraska, and beyond question, when the Texas species of gasteropods and pelecypods have been reported in full, there will be many more species common. It seems very probable that the Permian of Kansas and Texas was at one time connected, and that it also stretched westward and northward to, and possibly beyond, the Rocky Mountains. Many of the early geologists connected with the geological surveys of the territories considered that the uppermost rocks of the Paleozoic in the mountain region was Permian, and so recorded it; but owing to the lack of paleontological evidence, but few, if any, have ever considered this classification correct. Only recently fossil horizons of great importance have been discovered in what will in the future be known as the mountain Permian. These fossils are in part the same as those found in the Permian of Kansas and Nebraska, but with them are numerous forms new to science which are decidedly Mesozoic in character. When the mountain formations have been thoroughly investigated, the Permian area of the United States will be materially increased.

Some may question whether there are any true Permian rocks[1]

[1] See PROSSER's discussion of this subject in Vol. III, JOUR. GEOL., pp. 789–796.

in America. A discussion of this subject cannot be taken up here, but the following notes are worthy of consideration. Of the forty-four genera of invertebrates known in the Kansas and Nebraska rocks, over three fourths of them belong to the Permian of the Orient. The remainder are nearly all American genera and are chiefly pelecypods. In referring to the English Permian it will be seen that there are reported thirty species of brachiopods and thirty-seven species of pelecypods, while in America, with a fauna only partially known, there are fifteen brachiopods and between forty and fifty species of pelecypods. Besides this, there is the disappearance of the Spirifers, the most of the Producti, and the most of the typical Coal Measure species.

Some have objected to the use of the term Permian to designate an American terrane. There seems to be no good reason for this. In this country, as in Europe and India, there is a series of rocks above the Coal Measures that cannot be consistently classified with them. While they are linked with the Paleozoic with unmistakable affinities, they are also bound to the Mesozoic by indubitable bonds. Since the term Permian has been in use many years to represent this formation, in this, as well as foreign countries, it seems ill advised at this time to introduce a new term to designate the American formations. We might as consistently cast off other period names that have had their origin in a foreign country. Since the Permian is a typical transition series, it seems advisable to speak of it as a geological period of the Paleozoic, and no longer consider it an epoch of the Carboniferous.

In order to show the close relationship of the American and foreign Permian, a table has been arranged which will give all of the genera known to the Kansas and Nebraska Permian, and also show their distribution in the foreign Permian. The resemblance is even greater than appears in the table, since it has been impossible to secure accurate data relating to many of the foreign genera

A TABLE GIVING THE KANSAS AND NEBRASKA (AND IN PART THE TEXAS) PERMIAN INVERTEBRATE GENERA AND THEIR DISTRIBUTION IN THE FOREIGN PERMIAN

	England	Russia	Germany	India	Kansas	Nebraska	Texas
Anthozoa.							
Zaphrentis	..	..	..	..	+	..	..
Chaetetes	+	+	..	..	+	..	..
Echinoidea.							
Archaeocidaris	+	+	..	..	+	+	..
Annelida.							
Spirorbis	..	..	..	..	+	..	+
Bryozoa.							
Fenestella	+	+	+	+	..	+	..
Polypora	..	+	+	+	+	+	..
Septopora	..	..	..	+?	+	..	..
Rhombopora	..	..	..	+	+	+	..
Fistulipora	..	..	..	+	..	+	..
Brachiopoda.							
Orbiculoidea	+	+	+	..	+	+	..
Productus	+	+	+	+	+	+	..
Chonetes	+	+	+	+	+	..	..
Orthis	..	+	+	+	..	+	..
Derbya	+	..	+	+	+	+	..
Enteletes	..	..	+	+	+	..	..
Ambocoelia	..	..	..	..	+	+	..
Seminula	+	+	+	+	+	+	..
Pelecypoda.							
Aviculopecten	+	+	+	+	+	+	+
Avicula	+	..	..	+	..	+?	..
Pseudomonotis	+	+	+	+	+	+	..
Pinna	+?	+	+?	..	+	+	..
Macrodon	+?	..	..	+	+	..	..
Myalina	..	+	..	..	+	+	+
Nuculana	..	+	..	+	+	..	..
Nucula	+	+	..	+	+	..	..
Yoldia	..	..	..	..	+	+	+
Bakevellia	+	+	+	+	+	+	+
Schizodus	+	+	+	+	+	+	..
Pleurophorus	+	+	+	+	+	+	+
Scaldia	..	..	..	..	..	+	..
Edmondia	+	+	..	+	+	+	..
Solenomya	+	+	+	..	..	+	..
Ceromya?	..	..	..	..	..	+	..
Sedgwickia	..	..	..	..	+	+	+
Chaenomya	..	..	..	..	+	+	..
Allorisma	+	+	+	+	+	+	+
Glauconema	..	..	..	..	+	..	..
Schaphopoda.							
Dentalium	+	..	+	..	+	+	..
Gasteropoda.							
Bellerophon	..	..	+	+	+	+	+
Loxonema?	+	+	+	..	+	..	..

A LIST OF THE KANSAS AND NEBRASKA PERMIAN FOSSILS [1]

	England	Russia	Germany	India	Kansas	Nebraska	Texas
Gasteropoda.							
Macrocheilus	+	..	+	+	+	..	..
Orthonema?	..	..	..	..	+	..	..
Aclisina	..	..	..	..	+	..	..
Strapharollus	+	..	+	+	+	+	+
Naticopsis	..	..	..	+	+	+	+
Pleurotomaria	+	+	+	+	+	+	..
Murchisonia	..	+	+	+	+	+	+
Cephalopoda.							
Orthoceras	..	..	..	+	..	+	+
Nautilus	+	..	+	+	+	+	+
Metacoceras	..	..	..	..	+	+	..
Phacoceras	..	..	..	..	+	..	..
Crustacea.							
Phillipsia	+?	..	..	..	+	..	..
Pisces.							
Styptobasis	..	..	..	..	..	+	..
Diplodus	..	..	..	..	..	+	..

	Nebraska	Kansas	Texas
Fistulipora sp	+	..	..
Chaetetes cf. *carbonaria* Worth	..	+	..
Zaphrentis sp	..	+	..
Archaeocideris sp	+	..	..
Archaeocideris sp	..	+	..
Spirorbis cf. *permianus* King	..	+	..
Spirorbis? orbiculostoma Swal	..	+	..
Spirorbis sp	..	..	..
Fenestella shumardi Prout	..	+	..
Fenestella sp	+	..	..
Polypora submarginata Meek	..	+	..
Polypora sp	+	..	..
Rhombopora lepidendroides Meek	+?	+	..
Rhombopora sp	+	..	..
Septopora biserialis Swal	..	+	..
Orbiculoidea sp	..	+	..
Orbiculoidea sp	+	..	..
Orbiculoidea sp	+	..	..
Productus semireticulatus Martin	+	+	..
Productus semireticulatus calhouni Swal	..	+	..
Productus nebrascensis Owen	..	+	..
Productus costatus Sowb	..	+	..
Chonetes granulifera Owen	..	+	..
Orthis sp	+	..	..
Derbya crassa M. & H	+	+	..
Derbya multistriata M. & H	..	+	..
Derbya robusta Hall	+	..	..
Meekella striaticostata Cox	+	+	+
Meekella shumardiana Swal	..	+	..

[1] The fossils reported from Kansas are those that have recently been reported by Professor Prosser. The Texas list has been reported by Professor Cummings, and the Nebraska from my collections.

A LIST OF THE KANSAS AND NEBRASKA PERMIAN FOSSILS—*continued*

	Nebraska	Kansas	Texas
Meekella sp	+	..	..
Enteletes hemiplicata Hall	+	+	..
Ambocoelia planoconvexa Shum	+	+	..
Seminula argentia Shep	+	+	..
Aviculopecten occidentallis Shum	+	+	+
Aviculopecten carboniferous Stevens	..	+	..
Aviculopecten maccoyi M. & H	+	+	..
Aviculopecten sp	+	..	..
?Avicula cf. *lanceolata*[1]	+	..	..
Pseudomonotis hawni M. & H	+	+	..
Pseudomonotis hawni ovata M. & H	+	+	..
Pseudomonotis cf. *variabilis* Swal	..	+	..
Pseudomonotis sp	+	..	..
Pinna peracuta Shum	+	+	..
Pinna sp. nov	+	..	..
Pinna sp. nov	+	..	..
Pinna sp. nov	+	..	..
Myalina recurvirostris M. & W	..	+	..
Myalina perattenuata M. & H	+	+	+
Myalina kansasensis Shum	..	+	..
Myalina permiana Swal	+	+	+
Myalina aviculoides M. & H	+	..	+
Myalina swallovi McChes	..	+	..
Myalina sp	+	..	..
Nuculana bellistriata attenuata Meek	..	+	..
Nucula cf. *beyrichi* Schauroth	..	+	..
Yoldia subscitula M. & H	+	+	+
Bakevellia parva M. & H	+	+	..
Schizodus curtus M. & H	..	+	..
Schizodus ovatus M. & H	+	+	..
Schizodus wheeleri Swal	+	..	..
Schizodus cf. *curtiformis* Walcott	..	+	..
Schizodus sp	+	..	..
Schizodus sp	+	..	..
Pleurophorus subcostatus M. & W	..	+	..
Pleurophorus cf. *oblongus* Meek	..	+	..
Pleurophorus subcuneatus M. & H	..	+	..
Pleurophorus sp	+	..	..
Pleurophorus sp	..	+	..
Scaldia sp. nov	+	..	..
Edmondia calhouni M. & H.?[2]	..	+	..
Edmondia cf. *nebrascensis* Gein	..	+	..
Edmondia sp	+	..	..
Edmondia sp	..	+	..
Solenomya sp	+	..	..
Solenomya sp	+	..	..
?? Ceromya sp. nov	+	..	..
Sedgwickia altirostrata M. & H	+?	+	..
Chaenomya minnehaha Swal	+	+	..
Chaenomya laevenworthensis M. & H	+	..	..

[1] Atlas of Fossil Conchology, Brown, Plate LXIX, Fig. 3.

[2] This has recently been referred to Pleurophorus. See Bull. U. S. Geol. Surv., No. 153, by STUART WELLER, p. 242.

A LIST OF THE KANSAS AND NEBRASKA PERMIAN FOSSILS—*continued*

	Nebraska	Kansas	Texas
Allorisma subcuneatum M. & H.	+	+	+
Allorisma cf. *elegans* King	+	..	..
? *Glauconome* sp.[1]	..	+	..
Dentalium meekanum Gein (?)	..	+	..
Dentalium sp.	+	..	..
Bellerophon montfortanus N. & P.	+	+	+
Bellerophon, cf. *sublaevis* Hall	..	+	..
Bellerophon marconanus Gein	+	..	..
Bellerophon sp.	+	..	..
Bellerophon sp.	..	+	..
Loxonema ? sp.	+	+	..
Macrocheilus angulifera White[2]	..	+	..
Orthonema ? sp.	..	+	..
Aclisina robusta Stevens	..	+	..
Aclisina swallovana Gein	..	+	..
Strapharollus subrugosus M. & W.	+	+	..
Strapharollus subquadratus M. & W.	..	+	+
Strapharollus pernodosus M. & W.	..	+	..
Naticopsis, cf. *remex* White	+	..	+
Pleurotomaria sp.	+	..	..
Murchisonia, cf. *nebrascensis* Gein	+	..	..
Murchisonia sp. nov.	+	..	..
Orthoceras sp.	+	..	..
Nautilus eccentricus M. & H.	+	+	..
Metacoceras dubium Hyatt	+	+	..
Metacoceras sp.	+	..	..
Metacoceras sp.	+	..	..
Phacoceras dumbli Hyatt	..	+	..
Phillipsia sangamonsis M. & W.	..	+	..
Phillipsia sp.	..	+	..
Styptobasis knightiana Cope	+	..	..
Diplodus sp. nov.	+	..	..

W. C. KNIGHT.

[1] Referred by STUART WELLER to Pinnatopora. See Bull. U. S. Geol. Surv., No. 153, p. 288.

[2] Conditionally referred to *Soleniscus angulifera*. See Bull. U. S. Geol. Surv., No. 153, p. 339.

THE DIAMOND FIELD OF THE GREAT LAKES

THE diamonds which have from time to time been discovered in the region of the Great Lakes of North America, now number seventeen, not including those of microscopic size. With the augmentation of the number of stones the problems arising out of their distribution in the glacial drift, and particularly those relating to the source or sources from which they have been derived, assume increasing interest.

HISTORICAL INTRODUCTION

The first mention of diamonds from this region in any scientific work appears in the *Mineral Resources of the United States for the year 1883–4*,[1] in which Kunz refers to the sensation caused by the reported diamond discovery near Waukesha, Wisconsin, in 1883. The "booming" of the property for diamond mines and the alleged discovery subsequently of two diamonds which Kunz found to have the aspect of African stones, very naturally led this eminent authority to discredit the discovery at this place of the larger stone as well, and to consider the entire affair as a so-called "plant" to influence speculation.

In the summers of 1887, 1888, and 1889, Mr. G. H. Nichols, of Minneapolis, assisted by Messrs. W. W. Newell and C. A. Hawn, of Rock Elm, Wis., prospected for gold in the bed of Plum Creek, Rock Elm township, Pierce county, Wisconsin. In the course of their work they found ten or more diamonds, varying in weight from ½ carat to 2 carats, besides a number of stones of microscopic dimensions.[2] The stones were found

[1] G. F. KUNZ: Mineral Resources of the United States, U. S. Geol. Surv. 1883–4 (1885), p. 732; see also Gems and Precious Stones of North America, New York, 1890, p. 35.

[2] G. F. KUNZ: Diamonds in Wisconsin, Eng. and Min. Journ., Vol. L, 1890, p. 686; see also a paper by the same author in Bull. Geol. Soc. Am., Vol. II, 1891, p. 638.

in the well-worn gravel of the bed of the creek, associated with garnets, gold, and platinum. Some were colorless but others were bluish or slightly yellowish. Three of the stones, which were sent to Mr. Kunz for examination, weighed respectively $\frac{2}{32}\frac{5}{2}$, $\frac{7}{1}\frac{}{6}$, and $\frac{3}{3}\frac{}{2}$ of a carat.

In November 1893, a white diamond of $3\frac{14}{16}$ carats, weight was brought to the writer in a collection of quartz pebbles, by Charles Devine, a farmer of Oregon, Dane county, Wisconsin. The stones had been found in October of the same year by a small son while playing in a clay bank on the farm of Judson Devine, in the town of Oregon, which is about twelve miles south of Madison.[1]

The writer's interest having been aroused in the occurrence of these stones, he began to investigate the Waukesha sensation and after some correspondence learned that a yellow diamond of over 15 carats weight was in the possession of Colonel S. B. Boynton, a jeweler of Chicago. From Mr. Boynton was learned the history of this stone, which was undoubtedly found as reported, at Eagle, near Waukesha, Wisconsin. The stone was brought to light in 1876 while digging a well on the farm then owned by Thomas Deveraux. The diamond was noted as something peculiar, and was given to Mrs. Clarissa Wood, who, with her husband, was a tenant on the property. Seven years later, in November 1883, while still ignorant of the real nature of the stone, she sold it to Mr. Boynton, at that time conducting a jewelry business in Milwaukee, for the sum of one dollar. Colonel Boynton submitted the stone to competent examination and learned that it was a diamond. Upon hearing of this Mrs. Wood offered to repurchase the stone for $1.10, and upon his refusal to accept this offer, brought suit against him to recover the full value of the stone. After extensive litigation the case was brought to the supreme court of the state, from which a decision was handed down in favor of the defendant, on the

[1] WM. H. HOBBS: On a recent Diamond Find in Wisconsin, and On the Probable Source of this and other Wisconsin Diamonds, Am. Geol., Vol. XIV, 1894, pp. 31-35; see also, Diamanten von Wisconsin, Neues Jahrb. f. Mineral., 1896, II, p. 249.

ground of his ignorance of the nature of the stone at the time of purchasing it.

The writer called upon Colonel Boynton at Chicago, and was allowed to examine the stone. Both it and the Oregon diamond were subsequently purchased by Tiffany & Co., of New York, and are still uncut in the Tiffany collection.[1]

Through Mr. Boynton the writer learned that a large diamond had been found in 1884 (this date should be 1886), by a farmer named Endlich, at Kohlsville, near West Bend, Washington county, Wisconsin. The stone had been brought to Mr. Boynton's shop for examination, and he had remembered it as a wine-yellow diamond, weighing 21¼ carats. After considerable correspondence this diamond was located by the writer in the possession of Mrs. Louis Endlich, of Kewaskum, Wis, the widow of the man who had discovered the stone in the neighboring town of Kohlsville. On visiting Kewaskum the writer was allowed to examine the stone, which proved to be in all respects as described by Colonel Boynton, and there is no doubt that the weight (21¼ carats) reported by him is approximately correct, since this stone is considerably larger than the one from Eagle. Mrs. Endlich stated that her diamond was found by her husband in the spring of 1886 while plowing a field on his farm in the town of Kohlsville.[2] This stone is still in her possession.

In 1894 Mr. Kunz reported the finding by Mr. Frank B. Blackmond of a diamond weighing almost 11 carats, at Dowagiac, Cass county, Michigan. This locality is to the southeast of Lake Michigan, on the Michigan Central railway, between Niles and Kalamazoo. The stone was found in the glacial drift and some search was subsequently made in the vicinity for other stones, but with negative results.[3]

[1] WM. H. HOBBS: *loc. cit.*, p. 32.

[2] WM. H. HOBBS: N. J. B., 1896, II, p. 33; also Bull. Univ. Wis., Sci. Ser., Vol. I, 1895, pp. 152–154; see also, G. F. KUNZ: Eighteenth Annual Report U. S. Geol. Surv. Pt. IV, 1895, p. 596.

[3] G. F. KUNZ: Sixteenth Annual Report U. S. Geol. Surv., 1895, Pt. IV, p. 596.

In March, 1896, a stone was brought to the office of the Wisconsin state chemist, at Milwaukee, which, on examination, proved to be a white diamond of nearly 6½ carats weight. It was found by Conrad Schaefer, a German farmer at Saukville, Ozaukee county, Wisconsin. In a letter to the writer, Mr. Schaefer says of this stone (translation):

> This diamond is from a little collection of gems, stones, and fossils, also Indian implements, all collected on my land. My land adjoins the Milwaukee River, and is a drift range running northeast and southwest. I had the stone about fifteen or sixteen years in my possession.

This diamond was purchased by Messrs. Bunde & Upmeyer, the well-known Milwaukee jewelers.[1]

In 1893 Messrs. Bunde & Upmeyer purchased from Mrs. G. Pufahl a white diamond of about 2 carats weight, said to have been found at Burlington, Racine county, Wisconsin. Little was learned at the time of the circumstances attending the finding of this stone, and the writer's subsequent attempts to get into communication with Mrs. Pufahl, though kindly assisted by Messrs. Bunde & Upmeyer, have not been successful. Like most of the others, this diamond was probably found in the glacial drift.[2]

The latest diamond to come from the region under consideration was found so recently that nothing is in print concerning it, except in the newspapers. It is a diamond of purest water, weighing 6 carats, and was found in 1897 by two small daughters of J. R. Taylor, at the town of Milford, Clermont county, Ohio. It is now owned by Herman Keck, of Cincinnati, and has recently been cut into the form of a brilliant. Before cutting a cast was taken of it and the stone is now being studied by Professor Thomas N. Norton, of the University of Cincinnati.

It is seen from the foregoing that no less than seventeen well-identified diamonds, varying in weight from ½ carat to over 21 carats, have been discovered in the region of the Great Lakes of North America. That a considerable number of others have been found which have not been reported because they have

[1] G. F. KUNZ: Eighteenth Annual Report U. S. Geol. Surv., 1897, Pt. V, p. 1183.

[2] G. F. KUNZ: *Ibid.*

escaped identification, hardly admits of reasonable doubt, when it is borne in mind that three of the stones found (including the two of largest size) remained in the hands of the farming population without their nature being discovered, for periods of eight and one half, seven, and over fifteen years, respectively. If it were possible to visit all the homes in the lake region, I have no doubt that many diamonds would be discovered in the little collections of pebbles and local "curios" which accumulate on the clock shelves of country farmhouses.

Since 1894, when the writer published a note on the Eagle, Oregon, and Kohlsville diamonds, and ventured to predict that other diamonds would occasionally be found in the glacial drift, they have been coming to light in this region, at the rate of about one each year, though not apparently as the result of search in any case.

PHYSICAL CHARACTERISTICS OF THE LAKE DIAMONDS

It will be profitable to consider the physical peculiarities of the several diamonds which have been found in the lake region, and to compare them with one another in order to determine whether points of resemblance or of difference are the more remarkable. They may be considered in respect to size, form, surface, and color. The observations of specific gravity and of index of refraction, which would be of great interest, have not as yet been carried out upon them.

Size.—The size of the lake diamonds is best indicated by their weights, which range from $21\frac{1}{4}$ carats (Kohlsville) to the microscopic diamonds of Plum Creek. In descending order the weights of the stones which have been examined are respectively $21\frac{1}{4}$, $15\frac{1}{32}$, $10\frac{7}{8}$, $6\frac{13}{32}$, 6, $3\frac{14}{16}$, $2\frac{1}{16}$, 2, $\frac{25}{32}$, $\frac{7}{16}$, and $\frac{3}{32}$ carats. While the average weight of these is over 6 carats, it cannot be considered an average for the region, since only the larger stones are likely to be discovered until a systematic search is undertaken in the region. At Plum Creek, where panning of the gravels was undertaken, the diamonds found were mostly small, the largest being of 2 carats weight.

Crystal form.—The crystal form of the lake diamonds furnishes the most important method of comparing them. The prevailing forms are the rhombic dodecahedron, the rhombic dodecahedron with vicinal faces of a hexoctahedron, and a hexoctahedron. The exceptions to the rule are found in the Saukville stone, a trisoctahedron; the Burlington stone, a tetrahedron; and the Milford stone, which from the newspaper accounts would seem to be an octahedron. Twinning was observed in one of the Plum Creek diamonds (in a hexoctahedron) and in the Burlington stone (in a tetrahedron).

The crystals possessing dodecahedral and hexoctahedral habits show, therefore, close affinities in their crystal forms, the Eagle and Kohlsville stones, which are crystallographically almost identical, being essentially intermediate between the Oregon dodecahedron and the Plum Creek and Dowagiac hexoctahedrons. On all the crystals the faces are rounded, and unequal development has produced distortion. The Eagle diamond approaches nearer to the ideal form than any of the others which I have examined.

Surface.—Surface markings are common to most of the stones. These are generally pittings, irregular in some cases, but generally circular or triangular. On the Eagle stone there are triangular elevations.

Color.—The color of the diamonds in this region varies from "white" to white tinged with green, and to pale yellow. The stones of Milford and Saukville are "white." White stones with faint grayish-green tinge (probably external) were found at Oregon and Burlington, and one from Plum Creek; while the Eagle and Kohlsville stones and some of those from Plum Creek are "Cape-white" (pale yellow). The several stones exhibit also varying degrees of transparency, the Milford stone particularly being of a remarkably pure water.

For purposes of comparison the most important facts regarding the larger diamonds have been brought together in the table on the opposite page.

Locality Where Found	Weight in Carats	Size	Crystal Form	Surfa
Eagle, Waukesha Co., Wis., on farm owned (1876) by Thomas Devereaux	15$\frac{3}{16}$		Rhombic dodecahedron, with vicinal faces of hexoctahedron. Only slightly distorted	Faces show also triang
Plum Creek, Rock Elm Township, Pierce Co., Wis. Ten stones, ranging in size from $\frac{1}{16}$ to 2 carats, and a number of microscopic size	(*a*) $\frac{1}{16}$ (*b*) $\frac{7}{16}$ (*c*) $\frac{3}{16}$		(*a*) Hexoctahedron (*b*) Elongated hexoctahedron (*c*) Elliptical hexoctahedral twin	(*a*) An L-sh the sid faces, grains (*b*) Surface crystall (*c*) Surface
Oregon, Dane Co., Wis., on farm of Judson Devine, 2½ miles southwest of village	3$\frac{13}{16}$		Rhombic dodecahedron (distorted)	Deeply pitte elongated
Kohlsville, Washington Co., Wis., on the farm of Louis Endlich	2$\frac{1}{4}$	20 mm × 13 mm × 10 mm	Elongated rhombic dodecahedron, with vicinal planes of hexoctahedron	All the faces ular shape
Dowagiac, Cass Co., Mich.	10$\frac{7}{8}$	13 mm × 9 mm × 11mm	Hexoctahedron	
Saukville, Ozaukee Co., Wis., on farm of Conrad Schaefer	6$\frac{13}{16}$		Flattened distorted trisoctahedron	Irregular, un deep octa on one sid
Burlington, Racine Co., Wis.	2$\frac{1}{16}$		Elongated tetrahedral twin	
Milford, Clermont Co., Ohio	6		Octahedron (?) (Now cut into brilliant)	Markings

DATA REGARDING DIAMONDS FOUND IN THE REGION OF THE GREAT LAKE

Crystal Form	Surface Markings	Color	Date of Finding	Date of Determination, and by Whom	Fi
hombic dodecahedron, with vicinal faces of hexoctahedron. Only slightly distorted	Faces show circular markings; also triangular elevations	"Cape White" (pale yellow)	1876	1883; 1893 G. F. Kunz, and the writer	Laborer e Mrs. Cla of Eagle
) Hexoctahedron	(*a*) An L-shaped depression on the side, with rounded faces, including sand grains	(*a*) White, with slight grayish-green tinge	1887	1891 G. F. Kunz	G. H. Nic neapolis
) Elongated hexoctahedron	(*b*) Surface covered with small crystalline markings	(*b*) Slightly yellowish	1888		W. W. Ne A. Haw
) Elliptical hexoctahedral twin	(*c*) Surface dull	(*c*) White tinged yellow	1889		Elm, Wi
hombic dodecahedron (distorted)	Deeply pitted with circular and elongated reniform markings	White, with slight gray-green tinge (probably superficial)	October 1893	November 1893 The writer, and later G. F. Kunz	Son of Ch Oregon
longated rhombic dodecahedron, with vicinal planes of hexoctahedron	All the faces have small irregular shaped pittings	Pale yellow	Spring 1886	September 1894 The writer	Louis End Kohlsvill
exoctahedron			1894 (?)	1894 G. F. Kunz	Frank B.
lattened distorted trisoctahedron	Irregular, uneven surface, with deep octahedral impression on one side	White, with two yellow stains	1880	March 1896 Dr. Mitchell, State Chemist, and later G. F. Kunz	Conrad Sch Saukvill
longated tetrahedral twin		Faint greenish white, perhaps external	?	1893 Bunde and Upmeyer, Milwaukee	Mrs. G. P Burling
ctahedron (?) (Now cut into brilliant)	Markings	White	1897	1898	Two small of J. R. Milford

Date of Finding	Date of Determination, and by Whom	Finder	Material in which Stone was Found	Present Owner	Where Described
1876	1883; 1893 G. F. Kunz, and the writer	Laborer employed by Mrs. Clarissa Wood, of Eagle	Gravel and clay of kettle moraine cemented by ferric oxide into hard yellow matrix	Tiffany & Co., New York	Am. Geol., 14 (1894), 31 N. J. B., 1896, II, 249
1887	1891 G. F. Kunz	G. H. Nichols, Minneapolis	Sand of stream bed containing quartz, magnetite, titanic iron, almandite, spessartite or hessonite, monazite, gold, and platinum	Do.	Eng. & Min. Jour., 50 (1890), 686
1888		W. W. Newell and C. A. Hawn, Rock Elm, Wis.		Do.	Bull. G. S. A., 2 (1891), 638 Min. Res. U. S., 1892 (1893), 759
1889				Do.	
October 1893	November 1893 The writer, and later G. F. Kunz	Son of Chas. Devine, Oregon	With pebbles of quartz in clay, kettle moraine	Do.	Am. Geol., 14 (1894), 31 N. J. B., 1896, II, 249 Min. Res. U. S., 1893 (1894), 682
Spring 1886	September 1894 The writer	Louis Endlich, of Kohlsville	Hard yellow ferruginous matrix in kettle moraine	Widow of L. Endlich, Kewaskum, Washington Co., Wis.	Am. Geol., 14 (1894), 31 Bull. Univ. Wis. (Sci.), 1 (1895), 152 18th Ann. Rept. U. S. G. S., Pt. V, 1183
1894 (?)	1894 G. F. Kunz	Frank B. Richmond	In kettle moraine		16th Ann. Rept. U. S. G. S., Pt. IV (1895), 596
1880	March 1896 Dr. Mitchell, State Chemist, and later G. F. Kunz	Conrad Schaefer, Saukville	In kettle moraine	Bunde & Upmeyer, Milwaukee	18th Ann. Rept. U. S. G. S. (1897), Pt. V, 1183
?	1893 Bunde and Upmeyer, Milwaukee	Mrs. G. Pufahl, of Burlington (?)	In kettle moraine (?)	Do.	Do.
1897	1898	Two small daughters of J. R. Taylor, of Milford	In or near kettle moraine	Herman Keck, Cincinnati	Not yet described

DISTRIBUTION OF THE LAKE DIAMONDS

The localities at which the diamonds have been found are distributed throughout an area nearly six hundred miles in length by two hundred miles in breadth, with its longer axis trending almost exactly northwest and southeast. Six of the eight localities are near the center of this territory, within an area about two hundred miles square, with its center near the city of Milwaukee.

All of the diamonds, with the exception of those from Plum Creek, were obtained from the deposits of glacial drift. The Plum Creek diamonds were obtained from the bed of the stream in immediate proximity to glacial deposits. It is clear, therefore, that the stones must have reached their late resting places in the drift through the agency of the ice mantle, and we should, therefore, study the directions of glacial movement throughout the region to discover the law of their distribution and to glean any facts that may be within our reach regarding the ancestral home, or homes, which they occupied before they were carried away by the ice.

The accompanying map of the lake region (Fig. 1) is based on the glacial map of Chamberlin[1], but revised and also extended to the north so as to include the results of later studies. The moraines in the vicinity of Lake Erie have been entered from Leverett's Monograph,[2] and those southwest of Lake Superior from a map by Todd.[3] The directions of the glacial striæ have been obtained from the works of Chamberlin, Leverett, and Todd already mentioned, and from papers by Lawson,[4] Smith,[5]

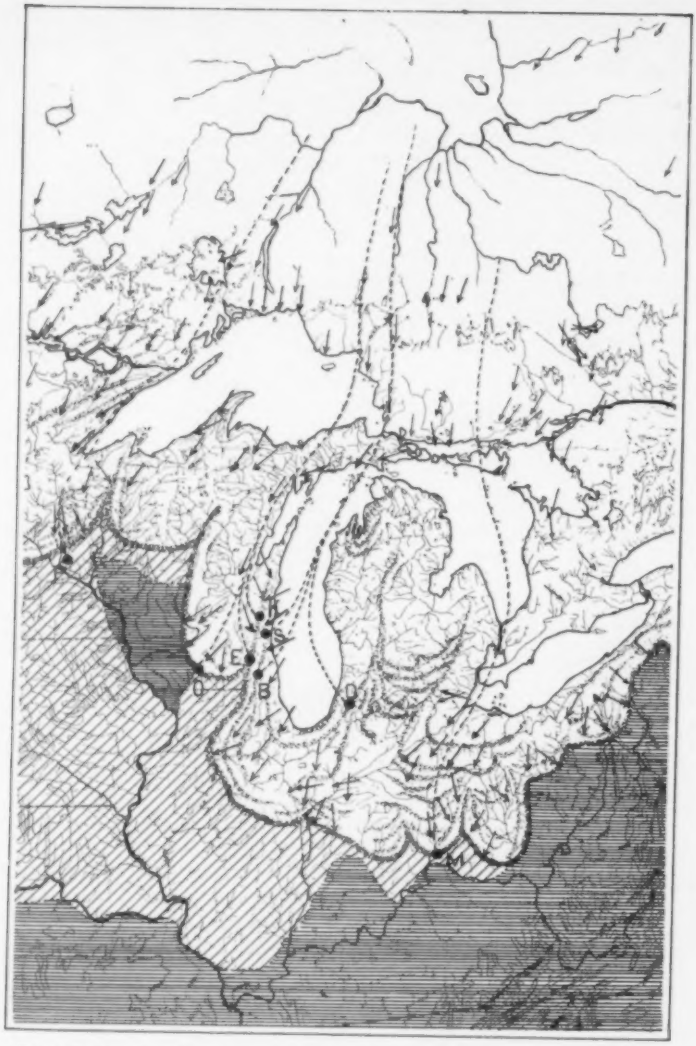
[1] T. C. CHAMBERLIN: The Rock Scorings of the Great Ice Invasions, Seventh Annual Report U. S. Geol. Surv. 1885–6 (1888), pp. 145–248, Pl. VIII.

[2] FRANK LEVERETT: On the Correlation of Moraines and Raised Beaches of Lake Erie, Am. Jour. Sci. (3), Vol. XLIII, 1892, pp. 281–301.

[3] J. E. TODD: A Revision of the Moraines of Minnesota. *Ibid.* (4) Vol. VI, 1898, pp. 469–478.

[4] A. C. LAWSON: On the Geology of the Rainy Lake Region. Geol. Surv. Can., Vol. III, 1889, Pt. I, Rept. F, Sheet No. 3.

[5] W. H. C. SMITH: On the Geology of Hunter's Island, and Adjacent Country. *Ibid.*, Vol. V, 1893, Rept. G, Sheet No. 23.



GLACIAL MAP OF THE GREAT LAKES REGION.

Driftless Areas. Older Drift. Newer Drift.

Moraines. Glacial Striae. Track of Diamonds.

Diamond Localities. E. Eagle O. Oregon

K. Kohlsville O. Dowagiac M. Milton P. Plum Crk. B. Burlington

Upham,[1] Low,[2] McInness,[3] and Bell.[4] In the Ohio area and in some others where a large number of observations of striæ have been collected the scale of the map has made it necessary to generalize, but these regions have been so carefully studied, both as regards moraines and scorings, that it was found easy to do this. In fact, within the territory of the United States the data at hand are sufficient for a fairly satisfactory plotting of the general direction of glacial movement at almost every point. Within the domain of Canada the great wilderness region has been covered only by reconnoissance surveys and except in the territory bordering on the lakes there exist only a few scattered observations from which to construct a map of glacial movement. In the district to the southeast of James Bay some surveys have been made but the material is not yet in print. In the region southwest and west of James Bay, which possesses also great interest, no data are available. Particularly in this latter region it is likely that striations will be found corresponding to different periods, owing to the fact that the ice from the Keewatin and Labradorean *névés* coalesced within this territory.

By plotting the diamond localities on the map it is seen that all but the Plum Creek locality are situated on the moraines of the later ice invasion, and that the latter locality is quite near to the moraine, within the area of overwash. It is also worthy of note that all but the Dowagiac stone were found in one of the marginal moraines which marked the greatest advance of the ice during its later invasion. The moraine which passes through Dowagiac corresponds to a somewhat later period, during the final retreat of the ice.

[1] WARREN UPHAM: Late Glacial or Champlain Subsidence and Re-elevation of the St. Lawrence River Basin, Am. Jour. Sci. (3), Vol. XLIX, 1895, pp. 1–18. Pl. I.

[2] A. P. LOW: Report on Exploration in the Labrador Peninsula, Geol. Surv. Can., Vol. VIII, 1896, Rept. L, p. 387, Sheets Nos. 585–588.

[3] W. C. MCINNESS: Sixth Report, Bureau of Mines, Ontario, 1896, Sheet No. 9.

[4] ROBERT BELL: Report on the Geology of the French River Sheet, Ontario, Geol. Surv. Can., Vol. IX, 1898, Rept. I, pp. 29, Sheet No. 125.

PROBABLE EXPLANATION OF THE DIAMOND DISTRIBUTION

The material from which the diamonds were derived must clearly have been to the northward beyond the lakes, in the wilderness of Canada. A method which may result in locating this material with some definiteness will be elaborated below. To explain the occurrence of so large a proportion of the stones in or near the outermost moraine, it is necessary to assume either that at the beginning of the second great advance of the ice the diamonds were embedded in a loose material easily transported, and hence largely removed before the stages of retreat, or that they were embedded in their matrix, which from its limited extent was largely abraded and removed by the ice during its initial stage.

The first is the more reasonable assumption, by reason of the wide fan of distribution of the diamonds, and the number which has been found warrants the assumption that the number of stones at the source of supply must have been very considerable. It is likely that for every diamond that has been found there are a thousand still undiscovered in the drift.

Professor T. C. Chamberlin has, at my request, very kindly given me his views on this question, and I have his permission to print the following from a personal letter:

> In regard to the explanation of the occurrence of the diamonds in the large moraines near the outer limit of the later invasion two explanations present themselves: First, the diamonds were separated from their original matrix in preglacial times by disintegration and accumulated in the bottoms of the valleys in the vicinity of their origin. The first glaciations were not sufficiently abrasive to remove the diamond-bearing gravels in the bottoms of the valleys, or at least not able to do so completely. The diamonds, therefore, do not occur frequently in the earlier drift material. Furthermore, the earlier drift material was less subjected to wash and now appears less abundantly as clean gravel and hence a less proportion of the diamonds that may have been embraced in it have been found. The chances of finding diamonds scattered throughout the till is of course relatively small.
>
> The second hypothesis postulates a sufficient interval between the earlier glacial invasion and the later to permit the disintegration of the diamond-bearing matrix and the freeing of the diamonds which became subject to transportation and accumulation in the wash from the moraines of the later drift.

This view also supposes that the glacial abrasion directly freed some of the diamonds.

Of course the two hypotheses might be conjoined and this would be reasonable enough if the diamond-bearing matrix were such as to be topographically protruding and be subjected to disintegration and wear during the interglacial interval.

Of the two hypotheses, I incline somewhat to the first, as I think it more likely that the diamonds would be accumulated in some notable quantity in the long preglacial period of disintegration than in the relatively short interglacial interval.

To me also it seems that the former hypothesis is the more probable one, for the reason given, and further, because, as will be seen from what follows, the broad fan of distribution of the diamonds would seem to require a somewhat extensive area of supply, unless it be assumed that this was very near to the "center" from which the ice moved.

THE ANCESTRAL HOME OF THE DIAMOND

The problem of locating the area from which the diamonds of the drift have been derived is a fascinating one, and, while the data now available are insufficient for its complete solution, they are of a kind to indicate that, with the increase of our knowledge likely to come in the next decade, the desired end may be reached.

The first question which naturally arises is whether all the diamonds that have been found in the lake region have been derived from a common source. While there is no certain evidence that they have, nevertheless it would seem to be probable. Diamond-bearing rocks are not so numerous that there is much likelihood of two unconnected areas being discovered in the region in question. Moreover, the occurrence of diamonds with somewhat similar crystal habits over so large a territory would seem to be significant. The Oregon, Eagle, and Kohlsville diamonds, since they were found in the Green Bay lobe of the ice mantle, a comparatively narrow area, must certainly be regarded as having a common source, and this must be, as the writer pointed out in 1894, either on the medial line of the lobe,

or still farther away to the northward. It is also fair to suppose that the Saukville, Burlington, and Dowagiac stones, though they differ from one another in habit as much as any three stones from the region, have also a common source, since they were located comparatively near to one another in the moraines of the Lake Michigan lobe. Of these latter, the Dowagiac diamond is a hexoctahedron, like the stones from Plum Creek and the closely related vicinal hexoctahedrons of Eagle and Kohlsville.

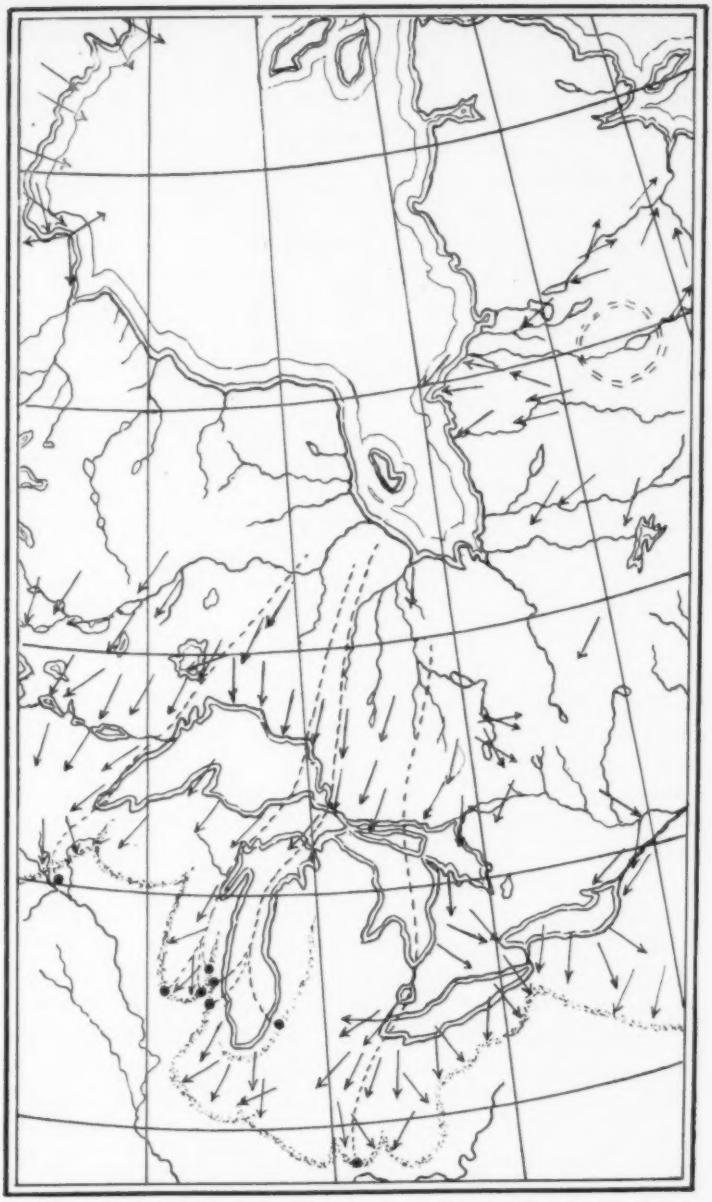
Provided a common source is assumed for all the diamonds of the region, this can only be located at the apex of the fan of diamond distribution on the hither side of the névé from which the ice moved. The wider this fan of distribution is found to be, the nearer is its apex carried towards the ice summit. The radial sides of the fan must be largely determined from the directions of striæ within the Canadian wilderness, of which an adequate number have been recorded only from the immediate vicinity of the Great Lakes. Beyond these borders the *tracking* of the diamonds can be carried out only with a certain approximation to correctness.

One of the results of the magnificent investigations of Tyrrell[1] and Low,[2] the one working to the west and the other to the east of Hudson Bay, has been the location of two main "centers" of the ice mantle corresponding to the Keewatin and Labradorean or Laurentide glaciers. The eastern of these "centers" or névés, and the one which must have principally affected the glaciation of the area of the Great Lakes, has been located by Low to the east of James Bay, a little to the eastward of the present watershed on the Labrador peninsula. This is brought out on the accompanying map (Fig. 2) by the directions of the striæ of this vicinity.

The tracks of the lake diamonds which have been delineated upon the map, converge in the direction of this névé, and show

[1] J. B. TYRRELL: Report on the Doobaunt, Kazan, and Ferguson Rivers, and the northwest Coast of Hudson Bay, Geol. Surv. of Can., Vol. IX, 1896, Report F, pp. 1–218.

[2] A. P. LOW: *loc. cit.*



GLACIAL MAP OF THE TERRITORY ABOUT HUDSON BAY AND THE GREAT LAKES.

that the apex of the fan of diamond distribution probably lies somewhere in the strip of territory bordering James Bay on the east.

DATA NEEDED TO DEFINITELY LOCATE THE SOURCE OF SUPPLY OF DIAMONDS

Before the home of the diamonds can be located with definiteness, it will be necessary to carry out several lines of investigation. Of first importance is it that the direction of ice movement be studied in as much detail as possible in the territory surrounding Hudson Bay on the southwest, south, and east. It will be important also to search the moraines south of the lakes, and particularly the marginal ones, for diamonds, since the evidence points to them as the principal repository of the emigrated stones. It is especially important to examine the moraines of Ohio, western New York and western Pennsylvania, in order to determine whether the fan of distribution extends farther in that direction. If this is true, the apex of the fan would seem to be located very near to the center of the Labradorean névé.

It has seemed to the writer that much might be gained by arousing an interest in the problem in the people who reside on or near the moraines, and suggesting to them that children particularly be urged to use their keen eyes in search for the diamonds that have been sown in the drift. To this end a brief statement has been prepared which sets forth what has already been learned regarding the lake diamonds, and explaining how rough diamonds may be distinguished from the ever present quartz pebbles. For identification of stones the persons finding them are referred to mineralogists, who are competent to pass upon gem stones, and who are willing to do so without compensation because of their interest in the problem. It is hoped that the editors of local newspapers in the morainal belt, to whom the statement will be mailed, will be willing to coöperate by printing it, and thus aid materially in disseminating the needful information.

WM. H. HOBBS.

REPLACEMENT ORE DEPOSITS IN THE SIERRA NEVADA

IT is well known that most of the gold deposits of the Sierra Nevada occur in true fissure veins in which the quartz appears to have been deposited in open cracks. This has been emphasized recently in a very clear manner by Mr. Waldemar Lindgren in two papers,[1] and he has also shown that the material of these veins was deposited by carbonated waters containing also silica and the precious metals. These waters have deposited their carbonates in very definite zones in the wall rocks, and the silica in the fissures. At some points, however, in the Sierra Nevada there are ore deposits which seem to have formed by the replacement of other material. Such appears to be the Diadem lode[2] southwest of Meadow Valley in Plumas county. This lode seems to represent a mass of dolomite and lime carbonate which has been replaced by quartz and chalcedony; masses of dolomite are still found on some of the levels. Iron and oxides of manganese are present, and according to J. A. Edman rich selenides of gold and silver combined with lead and copper occur as a rarity. Some of the manganese is in the form of the silicate, rhodonite. A certain portion of the lode is composed of little elliptical bodies which according to Mr. Charles Schuchert of the U. S. National Museum represent the silicified tests of foraminifera of Carboniferous age belonging to the genus Loftusia. The shells of Loftusia were originally carbonate of lime. These fossils were found by Mr. J. A. Edman, the proprietor of the mine, and forwarded to the Geological Survey for determination. They sometimes form considerable bunches, the interspaces between the elliptical tests being filled with secondary silica, or in some

[1] Bull. Geol. Soc. of America, Vol. VI, pp. 221–240.

Gold Quartz Veins of Nevada City and Grass Valley, Seventeenth Ann. Rep. U. S. Geol. Surv., Part II.

[2] See Bidwell Bar folio of the U. S. Geol. Survey.

cases being open. Other specimens of a fine-grained red siliceous rock which forms part of the lode, appear to represent a calcareous shale subsequently silicified. The red rock contains very abundant bodies, smaller than the Loftusia determined as such, but probably also of foraminiferal origin. Whatever the original nature of these smaller tests, they are now composed of granular quartz like the Loftusia. There is here unequivocal evidence that a considerable mass of carbonates has been replaced by silica. A large portion of the vein material containing the precious metals of the Diadem lode is chalcedony. The same waters which deposited the quartz and chalcedony and replaced the carbonates of the foraminifera tests are without doubt responsible for the gold, silver, manganese, etc., found in the deposit. This vein deposit may therefore be called a replacement deposit. The Diadem lode lies in the fault zone along which displacements have formed the steep slope east of Spanish Peak. There is also evidence of faulting in comparatively recent times at the lode itself.[1] It is without doubt along these faults that the waters containing the silica, etc., of the deposit have found their way from below. Such being the case it is likely that a certain portion of the secondary material may represent a true vein deposit, but it is probable that the larger part of the lode, which is represented by Edman as being in places sixty feet wide, may be called a replacement.

Professer Whitney inclined to the belief that the great quartz veins of the mother lode represent the replacement of bodies of dolomite. As Lindgren remarks,[2] however, this theory has not been supported by more detailed investigation. H. W. Fairbanks has suggested that these very large veins of pure quartz, sometimes forty feet in width, have resulted from the replacement of dikes of basic igneous rocks. The mechanical difficulty of accounting for the existence of such wide fissures, and the fact that the vein matter in these large masses seldom shows a banded structure such as might be expected from the deposit of

[1] Seventeenth Ann. Rep. U. S. Geol. Surv., Part I, p. 553.

[2] Bull. Geol. Soc. Am., Vol. VI, p. 235.

successive layers of quartz in an open space, are urged by Fairbanks as difficulties in the way of calling these veins filled-in fissures. The gradual replacement of the constituents of dike rocks by the vein material would perhaps account for the great size of the veins as well as their lack of banded structure. However, quite recently Lindgren[1] has brought forward a point as to the different character of the silica deposited as replacement material by a metasomatic process and that deposited in open spaces, which may serve as a criterion to determine, with the aid of the microscope, the two classes of deposits. Lindgren, after referring to the strong solvent nature of carbon dioxide and of alkaline carbonates, and the inert character of silica as a solvent, writes:

> Silicification by the cementation of shattered rock masses by silica is, of course, a common occurrence in and near quartz veins. But silicification by replacement is a less common process, and is observed chiefly in the case of easily soluble rocks, such as limestone or calcareous shales, when it results in fine-grained or cryptocrystalline aggregates of silica. In the metasomatism of bodies of massive rocks penetrated by chemically active solutions silica is formed in many ways, as by the carbonatization of silicates and sericitization of the feldspars, and if no open spaces are available much of this free silica will be deposited within the rock, usually as fine-grained aggregates more or less mixed with opal and chalcedonite. If no material were added the final result of this would not, however, be a silicification, but merely an increase in the total free quartz of the rock. But in case the rock mass is cut by fissures it appears that most of the resulting free silica is not deposited in the rock, but finds its way out in the open ducts, where, if the solution is supersaturated, it will be deposited. . . . . .
>
> As for the other possible process of silicification, or a dissolving of the original mineral and a deposition of silica *pari passu*, it occurs chiefly in easily soluble minerals, such as calcite. In case of the ordinary rock-forming silicates it is apparently not common. The resulting silica is generally in the form of fine, cryptocrystalline aggregates. Rocks silicified by either of these metasomatic processes, or by a combination of both, may occur, but, so far as the writer's experience goes, are not often encountered as wall rocks of auriferous quartz veins. But neither of these processes can have produced the massive, white, coarse-grained quartz of gold veins belonging to the normal type. This quartz, which contains native gold and sulphides, shows,

[1] The Mining Districts of the Idaho Basin and the Boise Ridge, Idaho, Eighteenth Rep. U. S. Geol. Surv., Part III, p. 645.

under the microscope, a peculiar, coarsely granular structure, the grains being partly bordered by crystallographic surfaces. This structure could have been developed only by free crystallization in open spaces. It is scarcely necessary to call attention, in addition, to the frequency of comb structure, etc., proving also the same kind of origin. This does not necessarily mean that all large bodies of quartz have been deposited in an open space, as large as the volume of quartz now is. Repeated openings of the fissure have doubtless often taken place.

Lindgren's results as to the usually finely granular character of the quartz deposited as a replacement are borne out in the Diadem lode occurrence, as may be seen by an inspection of Plate V on which are represented two photomicrographs, one of a thin section of the red siliceous rock of the Diadem lode without the analyzer, in which may be seen the outline of one of the elliptical bodies previously referred to as being probably of organic origin, and the other exactly the same view with the analyzer, in which the finely granular character of the quartz is shown. No careful microscopic examination of the quartz of the large massive veins of the southern part of the lode has, so far as I know, been made. Three thin sections from the croppings at the Peñon Blanco mine in Mariposa county (see Sonora folio) show that considerable patches of the quartz have the same optical orientation throughout, indicating large crystals and consequently deposition in an open space. It appears, therefore, likely that the huge quartz masses, some of them twelve meters in width, were deposited in open fissures and are not replacement deposits. The large size of the masses of quartz having apparently the same optical orientation throughout and the lack of banding may indicate merely quiet conditions during deposition and lack of interruption of the process.

To certain masses that form portions of the Mother lode a somewhat different origin must be assigned. I refer to the oft-described deposits composed of quartz, and calcium and magnesium carbonate, and mariposite. Lindgren considers[1] that these large masses represent nothing but altered serpentine, and asserts that abundant transitions may be found to prove this, as may

[1] Bull. Geol. Soc. Am., Vol. VI, p. 235.

be plainly seen at the App mine at Quartz Mountain in Tuolumne county. He considers this conversion readily explained when it is considered that serpentine is easily decomposed by carbonated waters into magnesite and chalcedonic quartz. In this case, as with the fissure veins, the essential feature is the introduction of the carbonated waters, and in confirmation of this may be cited the composition of this peculiar alteration product as given later in the table (Analysis No. 1508). The atomic composition of this rock is quite similar to the atomic composition of serpentine with the addition of carbon dioxide; while the difference in mineral composition is very striking, the original serpentine being a silicate and the alteration products carbonates. Such a deposit cannot be called a vein and it is likewise from the above standpoint not a replacement deposit, for the original elements are largely still there but in new combinations. There are some facts which will now be presented which at first glance suggest that the quartz, carbonate and mariposite deposits above described have not originated from the alteration of serpentine in place, but have resulted from the metasomatic alteration of dikes rich in soda, and hence may be called replacement deposits.

Lying just east of Moccasin Creek[1] in Tuolumne county, is a white dike which extends from the mouth of the creek in a southeasterly direction. The larger portion of the dike lies east of the creek and crosses the road to Priest's about 0.6 kilometers east of the bridge over Moccasin Creek. This dike has been rather fully described in a previous publication.[2] It is composed largely of soda-feldspar or albite, with quartz and muscovite locally abundant. A green aegerite-like mineral, and radial tufts of bluish amphibole are likewise present at some points. Throughout the greater part of its course the dike is bordered by serpentine on the west and greenstone on the east.

At numerous points this dike has been exploited for gold. Some of it is plainly mineralized, containing specks of iron

[1] See Sonora folio of the Geological Atlas of the U. S.

[2] Seventeenth Ann. Rep. U. S. Geol. Surv., Part I, p. 664.

pyrite. The rock is often very white and hard and is called quartz by some of the miners who are exploiting it. Three samples of this soda-feldspar dike from the Wheeler and Hill claim were assayed with the following results:

ASSAYS OF THE SODA-FELDSPAR DIKE OF THE WHEELER & HILL CLAIM

	2005-A	B	C
	Ounces	Ounces	Ounces
Gold	0.10	0.02	none
Silver	0.15	0.12	none
Authority	C. E. Munroe	Selby & Co.	Selby & Co.

The gold and silver and the iron pyrite appear to be disseminated through the dike rock, for no little veinlets are to be noted in the specimens assayed, as is the case in some of the mineralized soda-feldspar dikes. At the Black Warrior mine on the Moccasin Creek dike there has been reported a valuable deposit of workable ore since the date of my visit (1897). In the tunnel of this mine a mineralized talc streak in serpentine contains sulphides of iron and gold and silver. As to whether the valuable ore body is in the dike rock or not I have no reliable information.

Along Kanaka Creek about 2 km east of Jacksonville is another soda-feldspar dike which is nearly in a line with that east of Moccasin Creek. This is likewise mineralized at several points. At the Willietta mine on the Kanaka Creek dike a considerable mass of the dike rock has been quarried out and treated as ore. This deposit was examined by a San Francisco mining engineer, Mr. Luther W goner, and I am indebted to him for the following information: About 3000 tons of the rock were milled; the top two or three feet of the dike yielding about $3 per ton. Subsequently Mr. Wagoner made a mill test of a face fifteen feet high, this containing about 78 cents per ton in gold. Another sample of thirty tons yielded 56 cents per ton in gold. The concentrates (probably chiefly iron pyrite) were found to

be quite poor, showing only about $14 per ton. The gold seems to lie largely along the seams and joints of the mass. The unweathered dike rock carries about ½ per cent. of pyrite in little cubes from 0.5 to 1 mm in diameter.

In Eldorado county similar dikes form the lodes of gold deposits. Two of these have been worked with some profit.[1] The claims are known as the Shaw and Big Canyon (Orofina) mines, and are indicated on the economic geological map of the Placerville folio. My attention was first called to the Shaw mine lode by Mr. Leo von Rosenberg who transmitted specimens of the rock showing the porphyry dike rock, and other specimens containing veins of quartz and veins of albite with free gold. The dike rock of the Shaw mine and also that of the Big Canyon mine contain iron pyrite rather abundantly in places. Calcite is scattered through the dike rock in little rhombs. The evidence at the Shaw and Big Canyon mines is that mineral waters have percolated through the dike rock and deposited the iron pyrite and calcite with some gold throughout portions of the dike, while the quartz has largely been deposited in little veins along with most of the gold. The veins of white albite in the Shaw mine rock are undoubtedly secondary, but probably represent the material of the dike leached out and redeposited. This in itself suggests that albite is a mineral which is readily dissolved, and Lindgren has found sodium one of the elements most readily removed from the wall rocks of quartz veins.

The Bachelor lode on the north bank of the Tuolumne River lies at the contact of a mass of serpentine with a lens of argillite supposed to belong to the Calaveras formation. Just east of the vein, in the clay schists within a width of thirty feet, are six or eight dikes, which usually run parallel with the strike of the schists, but at two points cut across the schistosity. Such a series of dikes might be called a multiple dike, following

[1] Am. Jour. Sci. Third Series, Vol. XLVII, 1894, pp. 470–471.

Engr. and Mining Jour., Nov. 19, 1892, article by C. A. AARON on the Shaw mine lode.

Am. Geol. Vol. XVII, 1896, p. 380.

KEMP, Ore Deposits of the U. S., New York 1896, p. 287.

Lawson,[1] as it is reasonably certain that at some depth below the surface they all come together. The dikes vary from two inches to two feet in width. Quartz veinlets, one with a convoluted course, cut both the schists and the dikes. Between the dikes and the ledge is a broken-up mass of the dike rock of a reddish-brown color, penetrated by quartz veinlets and seams of dolomite, and apparently in a fair way to form a lode, like that immediately west, if the alteration should go farther. This mass seemed a friction breccia and would indicate movement and faulting along the lode. A microscopic examination of this breccia showed it to be made up of fragments of the dike rock cemented by dolomite and quartz. Throughout the rock, as well as in the dikes just east, is scattered iron pyrite in minute specks. The brown color is due to abundantly disseminated limonite. The microscope shows the dike rocks, where not replaced by silica and carbonate, to be composed almost entirely of interlocking grains of soda-feldspar with some larger twinned feldspars, in fact identical as to composition with other similar soda-feldspar dikes. There thus seemed to be evidence here that the dike rock has undergone replacement. To determine what alterations had taken place in the dikes some partial chemical analyses were made as follows:

PARTIAL ANALYSES OF SODA-SYENITE AND ITS REPLACEMENT ALTERATIONS BY DR. H. N. STOKES

	No. 1521	No. 1509	No. 1512	No. 1508
SiO_2	67.53	52.83	42.48	37.58
$CaCO_3$	none	9.64	13.43	5.78
$MgCO_3$	none	7.38	8.17	46.82
$FeCO_3$	none	.98	5.88	6.35
FeS_2	....	.77	.40	none
K_2O	.10	.35	2.67	0.23
N_2O	11.50	7.87	4.79	trace
Residual CO_2	none	.59	2.23	2.45

[1] American Geologist, Vol. XIII, p. 293.

Dr. Stokes states that the residual CO_2 is the excess above that required for $CaCO_3$ and $MgCO_3$, and is in 1508 at least clearly present as $FeCO_3$. Assuming the residual CO_2 is in the form of $FeCO_3$ in 1509 and 1512 also, I have calculated the amount of this in each case and inserted it in the analysis. The analysis as completed by Dr. Stokes contained no estimate of the $FeCO_3$.

No. 1521 is a specimen of the Moccasin Creek dike, and composed of nearly pure soda-feldspar. The rock contains no carbonates.

No. 1509 is from one of the soda-feldspar dikes in argillite just east of the Bachelor mine deposit.

No. 1512 is a more altered specimen of the soda-feldspar rock from another branch of the multiple dike of the Bachelor mine.

No. 1508 is the Bachelor lode material itself, composed of quartz, carbonates, and mariposite.

In this series there is the clearest evidence of a diminution of silica and sodium and an increase of carbonates from the fresh dike rock represented by No. 1521 to the lode material represented by No. 1508. There is, however, a decided jump in the magnesian carbonates in Nos. 1509 and 1512, which are certainly altered soda-feldspar dikes, to the magnesian carbonate in the lode material 1508. There being a mass of serpentine immediately west of the lode, and magnesium being readily soluble in carbonated waters, no one will doubt that the magnesium, both in the lode and in the dikes, came orginally from the serpentine. The possibility therefore arises that the association of the dikes and the carbonate lode is merely accidental. In that case we are forced to adopt Lindgren's hypothesis as to the origin of the lode itself, and to suppose that the alteration of the dikes is merely due to its proximity to the lode, itself formed by the alteration of serpentine. A case entirely similar is that of a mass of shale adjacent to serpentine. An analysis of the shale next to the serpentine may show a decided content of magnesia, but this does not prove the origin of the serpentine from the shale, but merely that waters charged with magnesium

from the serpentine have soaked into the shale and deposited their burden.[1]. The above facts cannot be regarded as evidence that the Bachelor lode has formed from the replacement of a soda-feldspar dike, but it gives conclusive evidence that such dikes readily undergo replacement when permeated by mineral waters. The soda-feldspar dikes occur very often in association with serpentine. This is the case in Plumas and Butte counties, where, however, no evidence of mineralization was noted. It is also the case at the Big Canyon mine, Eldorado county, and at the Willietta, Bachelor, Black Warrior, and Wheeler and Hill mines in Tuolumne county, and at various points north of the Merced River in Mariposa county. The dikes are not confined to the serpentine, however, although, so far as I know, they are nearly always in the neigborhood of this rock. One dike, however, more than a kilometer in length was noted in the sediments of the Calaveras formation, the nearest mass of serpentine being four kilometers distant. Open cuts at numerous points indicated that this dike had been prospected for gold. There is also a syenite dike in the slates of the Mariposa formation by the tollhouse west of Princeton, along which are small quartz veins. This dike is likewise mineralized, containing lime carbonate very abundantly and pyrite. At the Shaw mine also the dike is in slates, probably of Carboniferous age. The usual association of the dikes with serpentine suggests an original genetic connection,but this has nothing to do with the mineralization of the dikes, which takes place irrespective of the immediate presence or absence of serpentine, although it is possible that magnesium carbonate is never present to any extent except when serpentine is immediately adjacent. The association of gold with soda-feldspar dikes, so far as my observation goes, is more frequent than with dikes of other rocks, and this may point to albite being a mineral more readily altered or replaced by mineralizing solutions than any other feldspar. Experiments have been made on the relative solubility of some of the feldspars in pure water and in water charged by carbon dioxide. Mr. George Steiger kept for one month one half grain

[1] For definite examples of this see Bull. Geol. Soc. Am., Vol. II, pp. 406–408.

of three powdered feldspars separately in 50 cm³ distilled water, at 70° F., with the following results:

	Percentage of alkali dissolved
Orthoclase	0.16 K_2O
Albite (Amelia Co., Va.)	0.07 N_2O
Oligoclase (Bakersville, N. C.)	0.09 N_2O

This would show a greater solubility for orthoclase than for albite, but it is more to the point to observe the relative solubility of the feldspars with water charged with carbon dioxide.

R. Müller[1] obtained the following results:

SOLUBILITY OF METAL OXIDES OF FELDSPARS IN CARBONATED WATER

	SiO_2	Al_2O_3	K_2O	N_2O	CaO
Orthoclase (Adular)	.1552	.1368	1.3527	.....	trace
Oligoclase	.237	.1713	.....	2.367	3.213

It is clear here that the soda of the oligoclase is more soluble than the potash of the orthoclase, and that the lime of oligoclase is more soluble than the alkali. No quantitative statement of the solubility of pure albite in carbonated waters has been noted. The apparent readiness with which the albite of the dike rocks described in the paper goes into solution and is again deposited as albite in cracks, seems certainly to indicate that under certain unknown conditions this mineral is readily soluble.

Dr. Becker[2] describes the Treadwell mine on Douglas Island in Alaska as being an impregnation of a dike of sodium syenite, which has been mineralized in apparently exactly the same way as the sodium syenite dikes of the Mother lode above described. Becker states that the Treadwell syenite is composed chiefly of albite with subordinate amounts of soda-lime-feldspar, augite, amphibole, and biotite.

The ore associated with the syenite is separable into two distinct varieties. Of these one consists of stringers of quartz carrying some calcite and occupying interstitial spaces between more or less decomposed syenite fragments.

[1] Braun's Chemische Mineralogie, 1896, p. 398.

[2] Eighteenth Ann. Rep. U. S. Geol. Surv., Part III, p. 38 and p. 64.

In such ore the pyrite is often grouped in bunches and at other times is disseminated through the quartz. The distribution of the pyrite seems to be without effect upon the tenor of this variety of ore, which is usually rich in proportion to the quantity of pyrite. The other variety of ore consists of fragments of the syenite which have been, as it were, *soaked* in the auriferous liquid. They are impregnated chiefly with carbonates and pyrite, only a little silica penetrating where there were no open fissures. The pyrite in this variety is also either bunched or disseminated, and all the mine foremen assert that where this pyrite is scattered, the ore is nearly or quite worthless. It appeared to me that the disseminated pyrite represents ferromagnesian silicates attacked by sulphydric acid or soluble sulphides, and study of the ore under the microscope lends strength to this hypothesis, though without absolutely proving it.

Wherever the ore is strongly mineralized the ferromagnesian silicates have totally disappeared from the syenite, and the pyrite is scattered in it in about the same manner as the iron-bearing silicates in the fresher material. On the other hand, as the bunches of pyrite are accompanied by much calcite they could not have been produced from any ordinary accumulation of ferromagnesian silicates, and I think such pyrite must have entered the rock in a state of solution.

The alteration of the soda-feldspar dikes seldom or never goes so far as to constitute a complete replacement of the original material, and the ores are, so far as I know, uniformly of low grade. Such ore deposits may perhaps be called *partial replacements*. According to Lindgren [1] the term *substitution* is sometimes used for deposits of this character. In a paper on the auriferous veins of Meadow Valley [2] Lindgren describes the alteration of granodiorite along fractures by solutions containing heavy metals and boron. The deposits consist of epidote, zoisite, pyroxene, tourmaline, quartz, mica, titanite, ilmenite, calcite, and auriferous sulphides. These lodes seem to be of the nature of replacements.

H. W. TURNER.

PLATE.

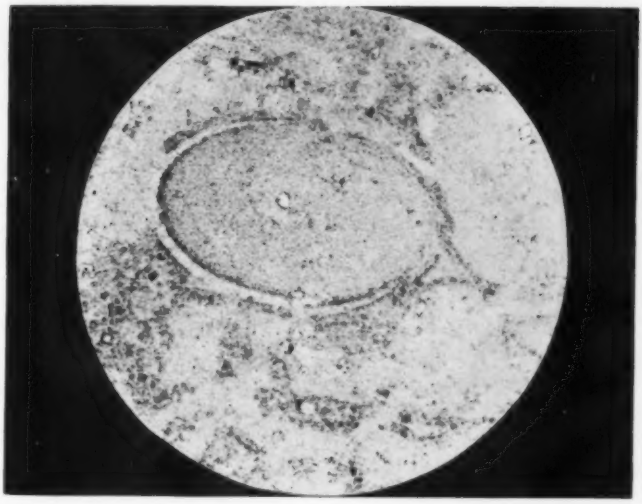
A. Photomicrograph of thin section of the red silicified shale of the Diadem lode, showing the outline of a foraminiferal test, without the analyzer, × 29.

B. Photomicograph of same view of thin section of red silicified shale as last, but taken with the analyzer, × 29.

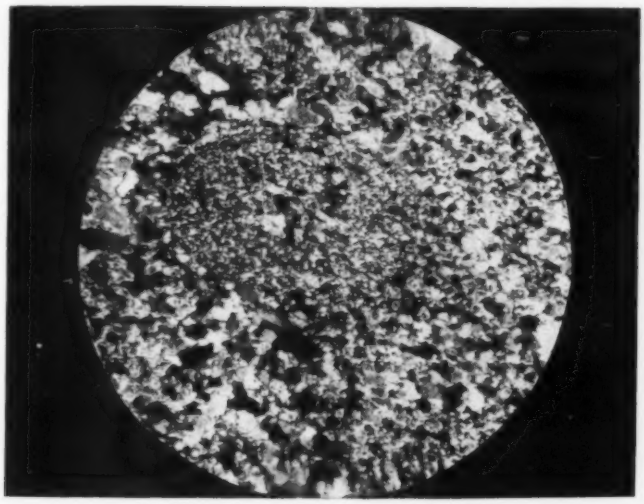
The two photographs by J. V. Lewis.

[1] Stanford University Engineering Journal, February 1898, p. 10.

[2] Am. Jour. Sci., Vol. XLVI, 1893, p. 201.



A × 29.



B × 29.

EDITORIAL

OTHNIEL CHARLES MARSH has left for himself as conspicuous a name and fame as could be desired by the most ambitious student of science. He had the advantages of a strong constitution, a clear intellect, indefatigable industry, a liberal fortune, a love of nature and the beautiful, a single purpose, and had no one dependent upon him for a share of his devotion. He began life in Lockport, New York, in October 29, 1831; as a boy was fond of hunting and fishing and out-door life; went to Phillips Andover Academy in 1852, graduated in Yale College in 1860, and took two more years of graduate work in the Sheffield Scientific School. In those days he was chiefly interested in chemistry and mineralogy. Then he went to Europe, where he spent three years studying mineralogy and paleontology, and in 1866 was appointed professor of paleontology in Yale University. From that time to the day of his death, March 18, 1899, he was devoted to original research, chiefly in the accumulation and study of fossil vertebrates, and to the building up of the Peabody Museum at Yale University, to which he gave at the close of his life all his collections and the great bulk of his fortune.

The contributions Professor Marsh made to science during his busy life are chiefly remarkable for the large number of startling new types of fossil vertebrates which he either first announced or brought to conspicuous notice by the number and perfection of the specimens representing them. His earlier investigations were in the Cretaceous deposits of the East; but his most remarkable discoveries were in the Jurassic, Cretaceous, and Tertiary beds of the Rocky Mountain regions, and in the plains east of them. In this latter region he conducted several expeditions of Yale students or graduates; and after the fossil-bearing beds were discovered, employed many collectors for

repeated years in digging out and shipping to the East the immense and rare bones, which were carefully worked out after reaching the Museum.

A bare list of the more important types of vertebrates, which he either first discovered or first elaborated, is of itself enough to exhibit the great place his labors must occupy in the progress of science.

In 1862, he announced the discovery of the Enaliosaurus in the Carboniferous rocks of Nova Scotia—a large Amphibian with biconcave vertebræ. It was Marsh who, in 1868, disputed the organic nature of Paleotrochis; and in the same year the metamorphosis of the Siredon was described. Fossil birds were discovered in both Tertiary and Cretaceous rocks, in 1870. The Rocky Mountain expedition of 1870 resulted in the discovery of the *Mauvaises Terres* formation in Colorado. In 1871, fossil serpents were reported from the Tertiary deposits of Wyoming, and a gigantic Pterodactyl from the Cretaceous of Kansas. In the following year Hesperonis, the wonderful bird with teeth, was announced, and the skull and limb bones of the Mosasaurus, the skeleton of Tinoceras, and remains of Quadrumana from the Eocene of Wyoming described. In 1873, new species of Ichthyornis, another toothed bird, were described, and a new subclass, Odontornithes, was founded, establishing the link between Birds and Reptiles. And the new order Dinocerata, with many enormous species, was defined and elaborated. In 1874, another expedition was conducted to the Rockies, and the Brontotheridæ were fully defined, and the fossil horses and their ancestors of the Tertiary were described. Also, a paper was written illustrating the small brain capacity of the early Eocene mammals. In 1875, a new order of Eocene mammals was announced, and an important statement of the affairs of the Red Cloud agency was made to the President.

In the following year the characters of the Dinocerata, the Tillodontia, the Brontotheridæ, the genus Coryphodon, and a new suborder of Pterosauria, were elaborated in important papers. In 1877, wonderful Dinosaurs from the Jurassic were

brought to light; and in 1878, new species of Ceratodus, of Dinosaurs, and of Pterodactyles were described. The next year he described another new order, the Sauranodonta from the Jurassic of the Rocky Mountains, and wrote the paper on Polydactyl horses, recent and fossil, setting forth in brief the history of the horse ancestry. The monograph on the Odontornithes was published in 1880. Numerous papers followed as the great and peculiar types of Dinosaurs were worked out; the Stegosaurus, the Brontosaurus, the Ceratopsidæ, Triceratops, etc.; and in 1896, an elaborate report on the Dinosaurs was published as a part of the Sixteenth Annual Report of the United States Geological Survey, not in the form of a monograph. In 1884. the skull of Pteranodon, the Pterodactyl without teeth, was elaborated, and the monograph on the Dinocerata, the gigantic extinct order of mammals, was published.

During the last ten years of his life, although there were fewer great discoveries to announce, the papers in elaboration of the immense accumulation of materials illustrating fossil vertebrates appeared in rapid succession; over one hundred titles having been added to the list of his published papers during these years. Among the more important contributions during this period were his discussions of the relations of *Pithecanthropus erectus;* on the age of the beds on the Atlantic coast which he called Jurassic; and important additions to knowledge of Dinosaurs, Tertiary and Cretaceous mammals, birds, fossil footprints; the description of a new Belodont reptile from the Connecticut River sandstone; and on sundry other subjects.

Professor Marsh was honored by election to membership and office in the principal societies and academies devoted to science in this and other countries. He was for two terms President of the National Academy of Sciences, and in 1897 received the Cuvier prize from the Institute of France. In 1886, he received the honorary degree of Ph.D. from the University of Heidelberg.

He died in the midst of active work. The manuscript for several other monographs on fossil vertebrates was left unfinished. Besides the large collections accumulated at his own

expense, which he had turned over formally to Yale University before his death, he left a large amount of material belonging to the United States Geological Survey, which had been collected under his direction and was undergoing description. It is probably true that no other one man has ever accumulated such a vast collection of remarkable and well preserved fossil vertebrates. H. S. W.

MR. THOMAS JONES has recently completed a reduction of his model of the earth which possesses sufficient merit and is of sufficient interest to geologists to warrant notice. The vertical exaggeration of his former globe was 36 to 1. The present is a reduction to 18 to 1. This relieves the exaggeration of most of its objectionable features and still leaves the relief impressive enough for lecture-room purposes. The first copy made has now been in use by the writer for several weeks with satisfactory results. The hypsometric data given by the Challenger Report have been followed for the oceanic basins.

T. C. C.

TO MEET an expressed desire for advanced summer courses in the fundamental principles of geology and glaciology suited to college teachers and advanced students, two courses will be offered during the first term of the summer session, July 1 to August 1, at the University of Chicago by Mr. Chamberlin. The first will consist of a discussion of basal questions and unsolved problems in geology taken up in historical order, so as to constitute in some measure a review of geological history. Following the method of multiple working hypotheses these questions will be discussed in the light of alternative theories. Some special attention will be given to a new series of hypotheses based upon the slow growth of the earth by meteoroidal accretions, these hypotheses being of such a nature as to develop with peculiar facility the strength and weakness of existing hypotheses and

to open up the problems widely. The atmospheric and climatic factors will receive special attention, as will also the reciprocal development of land and sea periods, the conditions of expansional, restrictional, and provincial life evolution, and the special functions of base-leveling, sea-shelves, epicontinental seas and atmospheric changes in controlling life progress.

The course in glaciology will embrace a discussion of the physics of glaciers, their chronological development, the distinctive phenomena of glacial deposits, and their interpretation.

The two courses will run parallel. They are only offered for the coming summer.

Besides these, the usual courses in physiography, meteorology, general and structural geology and field work will be offered by Professor Salisbury, assisted by Messrs. Goode, Atwood, Calhoun, and Finch.

ERRATUM

On p. 225 of the current volume, for "The glacier on Mount Iztacciahuatl is advancing" read: the glacier on Mount Iztacciahuatl is retreating at the rate of about two meters a year. H. F. R.

SUMMARIES OF CURRENT NORTH AMERICAN PRE-CAMBRIAN LITERATURE.[1]

SMYTH[2] reports on the crystalline rocks of St. Lawrence county, and particularly the towns of De Peyster, De Kalb, Hermon, Edwards, Canton, Russell, Potsdam, Pierrepont, and Parishville; together with points reëxamined in the towns of Gouverneur, Rossie, and Fowler, which were covered in the examination made during 1893. The crystalline limestones, for which, in a previous report, the name Oswegatchie series was suggested, form belts stretching in a northeast-southwest direction. Four belts comprise a large proportion of the crystalline limestones of the region examined. The largest, the Gouverneur belt, extends from Antwerp to probably two miles south of Canton village. Northwest of this belt another belt extends from Theresa, across Rossie and Macomb, into De Peyster. This belt is perhaps separated from the first belt by narrow strips of gneiss, along the northern boundary of Gouverneur, although the precise extent of the gneiss belts is undetermined. The third belt, the Edwards belt, to the south of the Gouverneur belt, and separated from it by a belt of gneiss, begins in Fowler, crosses Edwards, and runs out in the western part of Russell. The fourth belt, the Diana belt, south of the Edwards belt, and separated from it by gneiss, crosses the towns of Pitcairn and Diana. In general, the limestones have their greatest development in the northwestern part of the region, decreasing as the eastern and southern parts of the district are approached.

The limestone is everywhere thoroughly crystalline, ranges in color from white to dark bluish-gray, and often contains disseminated and aggregated silicates, of which the more important are serpentine and tremolite.

The term gneiss is used to include rocks ranging from acidic to basic, from fine to coarse grained, and from distinctly gneissoid, or even schistose, to entirely massive. They constitute a complex series,

[1] Continued from page 205, Vol. VII., JOUR. GEOL.

[2] Report on the crystalline rocks of St. Lawrence county, by C. H. SMYTH, JR.: From the Fifteenth Ann. Rept. State Geologist, in Ann. Rept. of N. Y. State Museum, 1895, pp. 481-497.

of rocks, differing somewhat in age, and largely, if not almost wholly, of igneous origin. Parts of this series are clearly younger than the limestones; other parts may be older than the latter formation, but there is nothing as yet to prove that such is the case. A probable exception to the latter statement is afforded by certain laminated gneisses, of limited extent, which appear to underlie the limestone, perhaps marking the base of the series.

Many of the gneisses have heretofore been believed to be sedimentary, and the evidence leading to the conclusion that they are largely igneous may be briefly summarized: There is the negative evidence of the absence of all structures pointing to sedimentary origin; the uniformity of composition and structure over wide areas, with changes by gradual transition; a common occurrence of massive cores, in every way identical with plutonic rocks; the presence of structures in the gneiss that would result from the application of pressure to igneous rocks; eruptive contacts between the abundant light-colored gneiss and the less common and older dark gneiss, together with widespread instances of inclusions of the dark gneiss in the light; the identity of the gneiss near Natural Bridge with the plutonic gabbro intrusive in the limestone; eruptive contacts at a number of places of the gneisses with the limestone.

Cushing[1] describes syenite-porphyry dikes in the northern Adirondacks. They are shown to be of pre-Cambrian age, but later than the gabbros and granites of the region. The syenite-porphyries constitute the complementary rocks to the diabases of the region, and together with them form an eruptive assemblage similar to that which characterized Keweenawan time in the Lake Superior region.

Cushing[2] describes the geology of Clinton county, New York. The pre-Cambrian succession, following Kemp, is as follows: (1) a basal gneissic series; (2) a series of schists and gneisses, with crystalline limestone; (3) igneous rocks of the gabbro type, intrusive in the first two series. All of these are overlain unconformably by Paleozoic sediments. This classification is tentative, and probably simpler than the one finally adopted is likely to be.

[1] Syenite-porphyry dikes in the northern Adirondacks, by P. H. CUSHING: Bull. G. S. A., Vol. IX, 1898, pp. 239-256.

[2] Report on the geology of Clinton county, by H. P. CUSHING: From the Fifteenth Ann. Rep. of the State Geologist, in Ann. Rep. of N. Y. State Museum, 1895, pp. 503-573.

1. The basic gneissic series appears in the western tier of townships of the county, with the exception of Clinton, Peru, and Ausable. The gneisses comprise several varieties, varying widely in texture and composition.

2. The series of schists and gneisses, with crystalline limestone, occurs only in Black Brook township. The limestone is coarsely crystalline, and much of it is quite pure, but very often it contains much green pyroxene.

3. The gabbros occur in three areas, which are outliers of the main gabbro massive of the Adirondacks. One is in Ausable township, extending north and west of Keeseville, and is the direct prolongation northeastward of a great gabbro ridge, which comes up to Keeseville from the southwest. The second forms Rand's Hill, in Beekmantown and Altona townships, twenty miles north of the first one. The third area forms the Catamount Mountain ridge, in southwestern Black Brook township.

After the intrusion of the gabbro, and prior to the Potsdam deposition, the region was subjected to intense metamorphism, resulting in the foliation and granulation of the rocks, with or without subsequent recrystallization.

Cushing[1] maps the boundary between the Potsdam and pre-Cambrian rocks north of the Adirondacks, from the line between Clinton and Franklin counties, west across Franklin county into St. Lawrence county, to a few miles west of Potsdam.

The sequence of rocks in the region is believed to be as follows:

1. A series of gneisses of great variety of structure and composition, in which all original structures are lost, of igneous origin, and in part at least of Archean age. They seem to grade into the basic gabbros of the region; at least the gabbros present phases not to be distinguished from the gneisses.

2. The Grenville series (Oswegatchie series) comprising quartzose gneisses and schists, quartz-feldspar-biotite gneisses, dioritic, and gabbroic gneisses, and occasional bands of coarsely crystalline limestone. These rocks are accompanied by belts of gneiss, similar to the older gneiss, which seem to be interstratified with the other rocks of this series, but whose relationships are doubtful. The gneiss of the Grenville series

[1] Report on the boundary between Potsdam and pre-Cambrian rocks north of the Adirondacks, by H. P. CUSHING: Sixteenth Ann. Rep. N. Y. State Museum, 1898, pp. 1-27. With sketch map.

differs in appearance from the older gneiss, and a considerable portion seems to be unquestionably of sedimentary origin, although dynamic metamorphism has obscured all traces of clastic structure and given the gneiss a foliation in common with the older gneisses, rendering the field relations obscure. From Parishville westward to Potsdam the Grenville series is more widely distributed, less faulted, and less completely metamorphosed, and hence with its sedimentary character less disguised, than the Grenville series farther east, probably because of its greater distance from the anorthosite intrusion. However, it seems to be beyond question that the eastern and western series are equivalent.

3. The anorthosite intrusion.

4. Later gabbros.

5. Granitic intrusions. The region was then subjected to intense dynamic metamorphism, after which occurred the intrusion of

6. Diabase and trachyte dikes.

7. Paleozoic rocks overlying unconformably all the preceding.

Kemp[1] continues his preliminary report on the geology of Essex county, N. Y., with an account of the detail geology of the individual townships. The additional observations have corroborated the conclusions reached in his previous report on this county,[2] concerning the main classification of the rocks of the area, although it is now doubtful if a sharp stratigraphic distinction can be drawn between Series (1) and (2).

Kemp[3] describes and maps the geology of the Lake Placid region in the Adirondacks of the northwest part of Essex county. Crystalline rocks of Algonkian age occupy a large part of the area. These include crystalline limestone, quartzite, granite, gneiss, and anorthosite. It is probable that some of the gneisses, and especially those associated with the limestones and quartzites, are altered sediments, and it is also probable that the gneisses with augen of labradorite are squeezed igneous rocks, but the investigation does not permit of their

[1] Preliminary report on the geology of Essex county, by J. F. KEMP: From the Fifteenth Ann. Rep. of the State Geologist, in Ann. Rep. of N. Y. State Museum, 1895, pp. 579-614. With geol. maps.

[2] See Report of State Geologist of New York for 1893, pp. 433-572. Summarized in Journal of Geology, Vol. VI., 1898, pp. 528-529.

[3] Geology of the Lake Placid region, by J. F. KEMP: Bull. N. Y. State Museum, Vol. IV., 1898, pp. 51-64. With geol. map.

separation. The anorthosites have intruded and metamorphosed the limestones and quartzites, and probably some of the gneisses. It has been noted that the anorthosite frequently passes outward by gradual transition into the dark gneisses with labradorite augen. Cutting all the above rocks are trap dikes, but whether pre-Cambrian or later, is unknown.

GENERAL COMMENT ON THE ADIRONDACK WORK

The above conclusions are of much interest as bearing on the general problems of the origin and age of the gneisses associated with the limestones of the Adirondack region. Kemp,[1] working on the eastern side of the district, has previously concluded that it does not appear certain that in the eastern Adirondack region there are any rocks older than the clastic series. As a result of field work on the eastern and western sides of the district, Van Hise[2] has held that most of the gneisses are clastic, but that a part of the red gneisses may be older than the clastic series, and therefore of Archean age. From the above summaries it appears that Kemp in his recent work still maintains the absence of the Archean. Cushing, working mainly in the northern part of the region, although overlapping Smyth's area a little way on the west, places in a lower series gneisses which he believes to be in part at least of Archean age, holds that a considerable portion of the gneisses associated with the limestones are unquestionably of sedimentary origin, and offers no evidence to show that any of the gneisses associated with the limestones are igneous and later than the limestone. Smyth, working entirely on the western side of the region, concludes that the presence of the Archean or basement gneiss has not been shown; that certain of the gneisses associated with the limestones may be sedimentary; but that the greater part of the gneisses of the district are igneous and later than the limestone. He thus agrees with Kemp on the point of the absence of the Archean.

It is to be remembered that Kemp, Cushing, and Smyth have been working in different areas. Each of them may be right as to the origin of the gneisses of his area and there may be present in the Adirondack district Archean, Algonkian, and post-Algonkian gneisses. Such is approximately the case in the Lake Superior region,

[1] Bull. G. S. A., Vol. VI., 1895, p. 251.

[2] Bull. 86 U. S. Geol. Survey, 1892, pp. 413-414, and sixteenth Ann. Rep. U. S. Geol. Survey, 1896, pp. 771-773.

where we have Archean and Algonkian gneisses and post-Algonkian granites.

While in different parts of the region the different conclusions above outlined have been reached, for the Adirondack region as a whole this much seems to have been shown. There is present a series of completely crystalline limestones and graphitic quartz-schists of sedimentary origin and pre-Cambrian age; closely associated with these are beds of graphitic and other gneisses, which are also sedimentary; cutting all the sedimentary rocks are gneisses of igneous origin, certain granites, and the great gabbro mass. That there is present a basal gneiss, while probable, has not been demonstrated. The question is still open. For much the larger part of the region also there remains for future work the discrimination of the sedimentary gneisses and the igneous gneisses of later origin.

The lithological similarity of the Adirondack sedimentary series with the Grenville series of the Original Laurentian district to the north has frequently been commented upon. In the latter district it has been possible lately to separate the sedimentary gneisses associated with the limestones from the true igneous gneisses of the Basement Complex by means of chemical analyses. The success of this method in the Original Laurentian district suggests that it may afford the best means for a satisfactory determination of the origin of the lower gneisses in the Adirondack district.

Miller[1] describes the occurrence of corundum in gneiss, syenite, and quartz-pegmatite of the Laurentian in the counties of Hastings, Renfrew, and Peterborough, in eastern Ontario.

Adams[2] reports on the geology of a portion of the Laurentian area lying to the north of the island of Montreal.

A previous report[3] summarized in this JOURNAL (Vol. VI., pp. 850-852), covers about the southeastern quarter of this area, and in a general way the conclusions reached for this southeastern area are applied to the larger area under discussion.

[1] Economic geology of eastern Ontario, corundum and other minerals, by WILLETT G. MILLER: Report of the Bureau of Mines, Ontario, Vol. VII., 1898, pp. 207-238.

[2] Report on the geology of a portion of the Laurentian area lying to the north of the island of Montreal, by FRANK D. ADAMS: Ann. Rep. Geol. Surv. of Canada, Vol. VIII., 1897, part J, pp. 184. With geological map.

[3] Ann. Rep. Geol. Surv. of Canada for 1894, Vol. VII., 1896, part J.

The Archean geology is summarized by the author as follows:

1. The Archean rocks in this area are of Laurentian age,[1] and are in part referable to the Grenville Series and in part to the Fundamental Gneiss.

2. The Grenville Series contains gneisses, as well as limestones and quartzites, which are of aqueous origin, having the chemical composition and the stratigraphical attitude of sedimentary rocks. With these are intimately associated, however, other gneisses which are of igneous origin.

3. The Fundamental Gneiss consists largely, if not exclusively, of igneous rocks in which a banding or foliation has been induced by movements caused by pressure.

4. Both series are penetrated by various igneous masses, of which the most important are great intrusions of anorthosite, a rock of the gabbro family, characterized by a great preponderance of plagioclase. This rock is in places perfectly massive, but generally exhibits the irregular structure which is so often observed in gabbros and which is brought about by a variation in the size of the grain or the relative proportion of the constituents from place to place. In addition to this original structure, the rock almost always shows a peculiar protoclastic, cataclastic or granulated structure which is especially well seen in the foliated varieties. This differs from the structure characteristic of dynamic metamorphism in the great mountainous districts of the world, having been produced by movements in the rock-mass while this was still deeply buried in the crust of the earth and probably very hot—perhaps near the melting point.

5. The same granulated structure is also seen in all those gneisses which have been formed from massive igneous rocks by dynamic movements.

6. The fine grained aqueous rocks of the Laurentian, on the other hand, have been altered chiefly by a process of recrystallization.

7. The "Upper Laurentian" or "Anorthosite Group" of Sir William Logan does not exist as an independent geological series—the anorthosite, which was considered to be its principal constituent, being an intrusive rock, and its remaining members belonging to the Grenville Series.

8. In all cases of supposed unconformable superposition of the

[1] In the sense of pre-Cambrian or Original Laurentian.

anorthocite upon the Laurentian gneisses, which have been carefully investigated, the unconformability is found to be due to intrusion.

9. The anorthosites are probably of pre-Cambrian age, and seem to have been intruded about the close of the Laurentian.

10. The Canadian anorthosites are identical in character with the anorthosites associated with the Archean rocks of the United States, Norway, Russia, and Egypt. The Norwegian occurrences, however, are probably more recent in age than those of Canada.

Adams and Barlow[1] give a general outline of geological work begun, but not yet finished, in the Laurentian of central Ontario, in the area comprising map sheets No. 118 and a portion of 119 of the Ontario series of geological maps, and indicate certain conclusions which seem likely to be reached concerning the origin and relations of the Grenville and Hastings series.

The Fundamental Gneiss occupies the northwestern, and by far the larger portion of the area. It consists of igneous rocks closely allied to granites, diorites, and gabbros, all showing more or less distinct foliation.

The Grenville and Hastings series are principally exposed in the southeastern portion of the area, the Grenville series appearing in a belt adjacent to the Fundamental Gneiss, and between the Fundamental Gneiss and the Hastings series.

The Grenville series is composed principally of gneisses identical in character with the Fundamental Gneiss, but it contains also, and is characterized by a small quantity of altered sediments, chiefly limestone. Some varieties of the gneissic rocks may owe their origin to the partial commingling of the sedimentary material with the igneous rocks by actual fusion. The strike of the foliation of the rocks of the series follows in a general way that of the Fundamental Gneiss. The Grenville series is believed to be a sedimentary series, later than the Fundamental Gneiss, which has sunk down into, and been invaded by, intrusions of the latter series when this was in a semi-molten or plastic condition.

The Hastings series is composed chiefly of thinly bedded limestones, dolomites, etc., cut through by great intrusions of gabbro, diorite, and granite. This series is believed to represent the Grenville

[1] On the origin and relations of the Grenville and Hastings series in the Canadian Laurentian, by F. D. ADAMS, and ALFRED E. BARLOW: Am. Journ. Sci., 4th ser., Vol. III, 1897, pp. 173-180.

series in a less altered form. That is, the Fundamental Gneiss, upon which the Hastings series was originally laid down, having at a subsequent time been softened by the influence of heat, and having under the influence of dynamic action eaten into and fretted away the overlying Hastings series, gave rise to an intermediate zone of mixed rocks which constitutes the Grenville series. The Grenville series may, however, represent only a portion of the Hastings series, and the work so far done has been insufficient to determine the stratigraphical position of this portion. It seems probable that the age of the Hastings series will be shown to be Huronian.

The Grenville and Hastings series are unconformably overlain by, and disappear to the south beneath, flat-lying Cambro-Silurian rocks.

Ells[1] gives a general account of the Archean of eastern Canada, including a review of the various classifications made by the earlier geologists, and their recent modifications. It is concluded that it is possible to reduce the great series of the so-called Laurentian rocks to two principal divisions, viz., a lower Basal or Fundamental Gneiss, in which all traces of sedimentation are wanting, and which may be regarded as representing in altered form some portion of the original crust of the earth; and a newer, secondary series, derived doubtless from the decay of the former, in which the evidences of clastic origin are manifest. On this basis the arrangement of the systems for eastern Canada would be as follows:

LAURENTIAN, NON-SEDIMENTARY

Basal or Fundamental Gneiss (Ottawa gneiss), representing in altered form the original crust of the earth, and the lowest known series of rocks; without evidence of sedimentary origin.

HURONIAN, PARTLY SEDIMENTARY AND PARTLY IGNEOUS

Grenville and Hastings series, comprising limestones, quartzites, gneisses, etc., of Ontario and Quebec, in the Ottawa district.

Schists and altered slates, chloritic and other crystalline rocks of the Eastern Townships of Quebec, and the Gaspé peninsula.

Felsitic and gneissic rocks of northern New Brunswick.

Gneiss, quartzite, and limestone, of the so-called Laurentian of southern New Brunswick, regarded as the equivalents of the Grenville

[1] Notes on the Archean of eastern Canada, by R. W. Ells: Proc. and Trans. Royal Society of Canada, 2d series, Vol. III, 1897, Sec. 4, pp. 117-124.

and Hastings series, felsites and schistose rocks, of the Coldbrook, Kingston and Coastal divisions, the apparent equivalents of the rocks of the Sutton Mountain anticlinal.

Felsitic and syenite rocks of eastern Nova Scotia and northern Cape Breton, with their associated crystalline limestones and serpentines.

CAMBRIAN

Cambrian slates, sandstones, and conglomerates.

General comment.—The succession and correlation proposed in the above papers by Adams and Barlow and by Ells are fundamentally different from the traditional one which has been held in Canada for many years. The first departure is in placing the Grenville and Hastings series as equivalent to the Huronian. Ells goes further and places with the Huronian all the sedimentary rocks of eastern Canada. This usage of the term Huronian restricts the Laurentian to the basal or fundamental gneiss. While the names are different, this is essentially the classification proposed by Van Hise in his Correlation Paper —Archean and Algonkian, in 1892. However, in place of Laurentian, he would use the term Archean. Also he would restrict the term Huronian to the rocks of the Original Huronian area and their equivalents. As it is impossible to be certain whether or not sedimentary series of eastern Canada not structurally connected with the Original Huronian are really equivalent to it, he has included the rocks above called Huronian under another name—Algonkian, a broader term covering all pre-Cambrian sedimentaries and contemporaneous eruptives, including the Keweenawan. The essential point, the existence of a non-sedimentary basal complex separated by a profound unconformity from a later pre-Cambrian series, partly sedimentary and partly igneous, is agreed upon.

Willmot[1] describes the geology of the Michipicoton mining division, which is limited on its eastern side by the 84th meridian, on the west by Lake Superior, on the south by latitude 47° 30′, on the north by latitude 48° 30′. Most of the rocks of the area belongs to the Laurentian and Huronian. The northern, eastern, and southeastern portions of the area are occupied by the Laurentian; the central and southwestern portions by the Huronian. The Laurentian is almost everywhere a fine

[1] The Michipicoton mining division by A. B. Willmot: Report of the Bureau of Mines, Ontario, Vol. VII, 1898, pp. 184–206.

grained gray gneiss, which often becomes granitic and coarser grained in texture. The Huronian rocks are most commonly massive diorites and diabases, and hornblende and chlorite-schists; less commonly, they are slates, felsites, quartzites, and sericite-slates. The Laurentian is frequently in eruptive contact with the Huronian.

In two areas, the Nipigon or Keweenawan rocks overlie the Huronian and Laurentian rocks. These areas are one two miles north of Cape Choyye and one on the peninsula of Gargantua.

Walker,[1] in 1897, describes the stratigraphy and petrology of the Sudbury nickel district of Canada. The oldest rocks of the district are gneisses of various kinds, which are regarded as of Laurentian age. Next in age to the gneisses is a belt of rocks consisting of quartzite, graywacke, amphibolite, mica-schist, phyllite, clay-slate, and altered volcanic breccia, which extends from the north shore of Lake Huron northeastward to Lake Mistassini, in the neighborhood of Sudbury, the belt being about twenty-five miles wide. The rocks of this belt are believed to be of Huronian age. The Huronian rocks have suffered severe metamorphism, and the original character of many of them cannot be made out. In and adjoining the Huronian belt are elliptical areas of later eruptive greenstone, in places intimately associated with and genetically inseparable from gneissoid and micropegmatitic granites. The nickel ore, principally pyrrhotite, occurs intimately intermingled with the eruptives, and is regarded as a concentration by differentiation from the eruptive magma. Cutting both the Huronian and the included nickel-bearing eruptives are masses of fine grained pinkish biotite-granite, sending apophyses into the surrounding rocks. This granite is found to have been intruded in two eruptions. The youngest rocks of the Sudbury district are olivine-diabases, which occur in dikes, cutting all the other rocks of the district.

Bell[2] reports on the geology of the French river sheet, which represents the country around the north end of Georgian Bay. Huronian rocks occupy the northwest corner of the sheet, and Laurentian rocks all the area to the southeast.

[1] Geological and petrographical studies of the Sudbury nickel district of Canada, by T. L. Walker, Q. J. G. S., Vol. LIII, 1897, pp. 40–66. With geol. map.

[2] Report on the geology of the French river sheet, Ontario, by Robert Bell: Ann. Report of the Geol. Surv. of Canada for 1896, Vol. IX, 1898, Part 1, pp. 29. With geol. map.

The Laurentian rocks in general resemble the Grenville series, which belong to the upper division of the Laurentian. They consist of red and gray mica and hornblende-gneisses in beds which can be traced with regularity for considerable distances, together with coarse hornblende and mica-schists and bands of quartz-rock with schistose partings. No limestones have yet been found among those rocks within the boundaries of the sheet, but in the Parry Sound district to the eastward, among similar strata, the writer has traced five bands of crystalline limestone like those of the Grenville series. The gneisses are distinctively stratified and regularly arranged in anticlinal and synclinal forms, according to the structural laws governing stratified rocks ; the average angles of dip are not steep, and in general, so far as their texture is concerned, the gneisses have the characters of altered sedimentary deposits. Cutting the granites are greenstone dikes, with an east and west direction.

The Laurentian rocks northwest of the Huronian area, outside of the area of the sheet, are considered to belong to the older division of the system.

The Huronian rocks comprise quartzites, sericite-, chlorite , hornblende-, and arkose-schists, clay-slates, graywackes, and dolomites. They have a general synclinal structure. The quartzites of the ridges northwest of Killarney form the southern side of the basin, and those of the Cloche mountains the northern side. Along the southern side of the major syncline are several subordinate folds. Associated greenstones are less conspicuous than in the Huronian rocks on the Sudbury sheet to the north. Those present are more largely developed in the tract on the south side of Lake Panache than elsewhere.

In the space between the Cloche mountains and the range which runs eastward from McGregor Point to Sturgeon Lake, including Bay of Is'ands, McGregor Bay, and the land thence eastward to the junction of the two chains, the rocks belong to a local division of the Huronian which may, for present convenience, be called the arkose series, with its associated rocks. Structurally this area would appear to occupy the central part of the synclinal area between the above-mentioned conspicuous quartzite ranges. Although various forms of arkose or graywacke are the prevailing rocks within this space, there are in different parts of it considerable quantities of gray quartzites and fine quartz-conglomerates, mixed agglomerates and breccias, sericitic and micaceous schists, impure dolomites and eruptive greenstones.

As to the origin of these rocks, the thick unstratified and brecciated graywacke or arkose may represent consolidated masses of volcanic ashes or mud with stones, which were thrown upon the land or into shallow water, while the stratified varieties may have consisted of similar ejectamenta, thrown into deeper water where they became arranged into layers as we find them. Some of these rocks, whether stratified or otherwise, may represent volcanic products which were originally thrown into the sea in a molten or heated condition and became broken up and almost completely disintegrated.

A study of the different phases of the graywackes and their associated rocks in this region would appear to prove that the former constituted the crude material from which both the quartzites and clay-slates were derived by the modifying and separating action of water. Again, by the action of time, pressure, heat, and other metamorphosing agents upon different varieties of graywacke, some of our granites, syenites, gneisses, and possibly other crystalline rocks, were probably formed.

Solid and slaty argyllites are found along Long Lake, an expansion of the Whitefish River, and slate conglomerates occur on both sides of Bear Lake and between Cat and Leech lakes. However, these rocks do not form a large proportion of the Huronian series in this district.

Impure magnesian limestones occur in the northern part of the Bay of Islands, in the northwest part of the township of Rutherford, and north of the area of the sheet near Lake Panache.

Between the Huronian rocks on the north and the Laurentian rocks on the southeast there is a belt of red granite, the Killarney belt, running from Badgely Island to Three-mile Lake. This granite is apparently of eruptive origin, and of later age than the quartzites. All along the line of contact with the Huronian the rocks give evidence of great disturbance. Huge portions, as well as many of moderate size, have been separated from both sides and have been mingled together and intermixed with finer débris, all being cemented into a coarse breccia.

The southeastern side of the Killarney belt of granite rests against the Laurentian gneiss, except in the interval from the southern point of George Island to the entrance of Collins Inlet, where a narrow belt of partially altered, fine grained, brittle, red and sometimes gray quartzite intervenes between the granite and the water of Georgian Bay. Further northeastward, or where the granite of the Killarney

belt comes into contact with the gneiss which prevails to the eastward, it is not always separated from the latter by a very distinct boundary. The rocks in some places pass into each other more or less gradually.

Barlow and Ferrier[1] discuss the relations and the structure of certain granites and associated arkoses on Lake Temiscaming. An examination of the contact of the granite and arkose shows a gradual and distinct passage of the granite into the arkose. Microscopically also there may be seen evidence of the decomposition of the feldspars of the granite, the breaking up of the feldspar and quartz, and finally the rearrangement and assortment of by water, indicating a gradual transition from the granite to the arkose.

The arkose is regarded as an Huronian sediment derived from and deposited on the granite. This is regarded as the only instance at present known in which the material composing the Huronian clastics can be clearly and directly traced both macroscopically and microscopically, to the original source from which it has been derived.

Comment.—The final statement is somewhat sweeping. Passing over the numerous instances of clear relations south of Lake Superior, it is necessary only to recall the instances close at hand, at Thessalon and Garden River, described by Irving, Pumpelly, and Van Hise, who found complete evidence of the unconformable relation between the Laurentian and Huronian, and of the derivation of the Huronian sediments from the Laurentian.

Burwash,[2] during the survey of the boundary line between the districts of Nipissing and Algoma in Canada, takes geological notes of the area traversed.

The run was made from south to north, from the upper waters of the Vermilion and Wahnipitae rivers, to within thirty-five miles of Lake Abittibi; and, with the exception of two areas of eruptive granite, the country was found to be underlain for the entire distance by Huronian rocks. The section is given in detail.

Tyrrell and Dowling[3] report on the country between Athabasca

[1] On the relations and structure of certain granites and associated arkoses on Lake Temiscaming, Canada, by A. E. BARLOW and W. F. FERRIER: Geol. Mag., Vol. V, 1898, pp. 39–41.

[2] Geology of the Nipissing-Algoma line, by EDWARD M. BURWASH: Sixth Rep. of the Bureau of Mines, Ontario, 1897, pp. 167–184.

[3] Report on the country between Athabasca Lake and the Churchill River in Canada, by J. B. TYRRELL, assisted by D. B. DOWLING: Ann. Rep. Geol. Surv. of Canada, Vol. VIII, 1897, Part D, pp. 120 with geol. map.

Lake and the Churchill River in Canada. The area covered by the report is bounded on the south by the Churchill and Clearwater rivers; on the west by the lower portion of the Athabasca River; on the north by Athabasca Lake, Stone River, with its expansions, Black and Hatchet lakes, Wollaston Lake, and Cochrane or Ice River; on the east by the lower part of the Cochrane River, Reindeer Lake, and Reindeer River.

Laurentian rocks, including hornblende-granites, biotite granites, muscovite granites, granitoid gneisses, gabbros, and norites, are found outcropping on the Churchill River from two miles below the mouth of the Mudjatick River eastward to the mouth of the Reindeer River; thence northward they occupy most of the eastern part of the district. Further west they are followed north to Cree Lake. In the northern part of the area they occupy most of the northern shores of Athabasca and Black lakes.

As far as at present known, the Huronian is represented in this district solely by three small areas on the north shore of Lake Athabasca. The Huronian here includes quartzites, calcareous sandstones and schists, conglomerate, hälleflinta, ferruginous chlorite-schists, and other green schists.

The Laurentian and Huronian are unconformably overlain by horizontal sandstones and conglomerates, called the Athabasca sandstone, which is placed in the Cambrian. However, these sandstones are similar to the sandstones found to the north associated with quartz-porphyries, diabases, etc., like those of the Keweenawan of Lake Superior, and there is little doubt that the two sets of rocks belong to the same horizon.

Tyrrell[1] reports on an exploration of the Doobaunt, Kazan, and Ferguson rivers northwest of Hudson Bay, the northwest coast of Hudson Bay, and on two overland routes from Hudson Bay to Lake Winnipeg.

Laurentian rocks, including granites, diorites, and granite and diorite gneisses, occupy a large part of the region crossed by the three main lines of travel — the Doobaunt River and Chesterfield Inlet, the Kazan and Ferguson rivers, and the west coast of Hudson Bay,— although their precise extent is unknown.

The Huronian rocks include three more or less distinct groups, the Marble Island quartzites, the greenish quartzites and graywackes, and

[1] Report on the Doobaunt, Kazan, and Ferguson rivers, and on the northwest coast of Hudson Bay, by J. B. TYRRELL: Ann. Rep. Geol. Surv. of Canada, Vol. IX, 1898, Part F, pp. 218. With geol. maps.

the more or less highly altered and often schistose diabases and gabbros. The largest area of Huronian is found along the coast of Hudson Bay from Baker's Foreland south to a point forty-five miles north of Cape Esquimaux, and inland for seventy miles up the Ferguson River. Other areas are found between Schultz and Baker lakes, near Lake Angikuni, near Kasba and Ennaidai lakes, the north shore of Doobaunt Lake, and the east shore of Wharton Lake.

The Huronian rocks are overlain unconformably by the Athabasca sandstone. As this sandstone is older than the flat-lying Cambro-Silurian limestone, and unconformably above the Huronian, it is assigned to the Cambrian, although no fossils were found in the formation. Lithologically the whole terrane presents a remarkable resemblance to the red sandstones and Cambrian quartz porphyries of the Keweenawan rocks of Lake Superior, and the two terranes are regarded as holding essentially similar positions in the geological time scale.

Low[1] reports on his explorations of the Labrador Peninsula, along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other rivers. Laurentian rocks occupy nine tenths of the area of the Peninsula. They include gneisses and schists, some of clastic origin, some of eruptive origin. The clastic portion is in nearly all cases the oldest.

The Huronian rocks comprise beds of arkose, conglomerate, limestone, shale, slate, sandstone, chert, quartzite, mica-schist, and eruptives, in part at least contemporaneous with, and at present represented by, schists characterized by chlorite, epidote, altered hornblende, hornblende, sericite, and hydromica; also diabases, diorites, and various granites. They occur in two large areas and several small ones. The large areas are along the East Main River from near the mouth inland for 160 miles, and the area of the large lakes southwest of Lake Mistassini.

The Laurentian and Huronian rocks are overlain with strong unconformity by a series of rocks classified as Cambrian, comprising arkose, sandstone, limestone, dolomite, felsitic shale, argillite, and argillaceous shale, together with gabbro, diabase, fine grained, decomposed traps,

[1] Report on explorations in the Labrador Peninsula, along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other rivers, in 1892, 1893, 1894, and 1895, by A. P. Low: Ann. Rep. Geol. Surv. of Canada, Vol. VIII, 1897, Part L, pp. 387. With geol. maps.

and volcanic agglomerates. The fine grained traps are interbedded with the clastic rock. No acid eruptives appear. On the east coast of Hudson Bay and at Chateau Bay near the eastern entrance of the Strait of Belle Isle, some of the traps have formed overflows on the surface, and are now represented by dark green, fine-grained melaphyres having large amygdaloidal cavities filled with quartz and agate. No fossils have been found in these supposed Cambrian rocks and their precise age and equivalency can only be conjectured. However, the mode of occurrence of thick beds of magnetic iron ore overlain by cherty, nonfragmental carbonates in this series, closely resembles that of the iron ores of the Lake Superior region described by Irving, Van Hise, and others. This, with other characters of resemblance, renders it almost certain that the two developments represent the same period, or, in other words, that the Animikie rocks of Lake Superior, assumed to be Lower Cambrian, are equivalent to the rocks here described as Cambrian in Labrador.

Low[1] reports on a traverse of the northern part ot the Labrador peninsula, from Richmond Gulf to Ungava Bay. Laurentian rocks occupy the greater part of the area. These are chiefly granites, more or less foliated. They are of different ages, but, except in a few cases, they cannot be discriminated. Cutting them are intrusive diabases.

Intimately associated with the granites is a series of more or less quartzose mica-gneisses and mica-schists, interbanded with hornblende-schists and hornblende-gneisses; and at times with quartz-magnetite gneiss. These gneisses and schists are supposed to represent a bedded series of rocks somewhat similar to the Grenville series. While most of the schists are thus probably very ancient, others may be of the same age as the Cambrian.

Cambrian rocks were met with along the east coast of Hudson Bay, to the northward of Cape Johns, and on the Larch River from its junction with the Kaniapiskau upwards for thirty miles. A section examined on the east side of Castle peninsula, on the north side of the outlet of Richmond Gulf, presents rocks closely resembling the Mesnard quartzites and the Kona dolomites of the Lower Marquette series of the south shore of Lake Superior, capped by a later outflow of trap, classed as Algonkian by Van Hise.

[1] Report on a traverse of the northern part of the Labrador peninsula, from Richmond Gulf to Ungava Bay, by A. P. Low: Ann. Rep. Geol. Surv. of Canada for 1896, Vol. IX, 1898, Part L, pp. 1-43. With geol. map.

Comments.—In the explorations by Tyrrell and Low, considering the time available and the ground covered, the determination of the geological series was necessarily of the most hasty nature. Nothing but the roughest petrographical discriminations could be made, and no structural work was possible. Their terms Laurentian, Huronian, and even Cambrian, therefore, indicate only the broad petrographical features of the rocks traversed, and do not stand for well defined series equivalent to the series so named to the south.

Following the usage of many of the Canadian geologists, the Cambrian is made to include rocks supposedly equivalent to the Cambrian, Keweenawan, and Animikie of the Lake Superior region, and Low carries it down even to include formations similar to Lower Marquette formations of the Lake Superior country. In the Lake Superior region, where most thoroughly studied, the Keweenawan and Huronian formations are separated from each other and from the Cambrian by well marked unconformities, unconformities uniformly recognized by geologists who have done close work in this region. These unconformities have been recognized also in other parts of North America. If the rocks above called Cambrian are really equivalent to the various Lake Superior series mentioned, then the extension downward of the Cambrian, across well established unconformities, to include such series, has no reasonable basis. However, in view of the scanty observations and the absence of connecting structural work, any correlation at present is little more than a suggestion, and for this reason it would be better to give the formations local names, as was done by Tyrrell in the case of the Athabasca sandstone. Thus would be avoided the confusion arising from the misuse of well defined and well established terms like Cambrian, Keweenawan, and Huronian.

Bailey[1] reports on the geology of southwest Nova Scotia. Cambrian rocks devoid of fossils occupy a large part of the area. The succession is, in ascending order, as follows:

I. Quartzite Division.
   (*a*) Heavily bedded bluish quartzites, alternating with much thinner beds of argillite.
   (*b*) Greenish-gray sandstones or quartzites, somewhat chloritic and less massive than in (*a*), and alternating with slates which are arenaceous below but become progressively more argillaceous above.

[1] Report on the geology of southwest Nova Scotia, by L. W. BAILEY: Ann. Rep. Geol. Surv. of Canada, Vol. IX, 1898, part M, p. 154. With geol. map.

II. Banded Argillite Division.

(*a*) Greenish-gray slates, becoming bluish or light gray, and passing upwards into

(*b*) Purple slates, marked in the lower beds by pale, yellowish-green seams, with faint bedding lines, which are wanting in the higher beds.

(*c*) Bluish-gray and gray slates, often with cloudings of green, purple, lilac, buff, or yellow, in places exhibiting a conspicuous banding or ribboning of the beds.

III. Black Slate Division.

Black, with some blue or gray slates, often studded with cubes of pyrites, and very rusty-weathering.

Comment.—Here again the Cambrian has been extended downward to cover rocks, devoid of fossils, which have been mapped as Algonkian by Van Hise.[1]

Dawson[2] presents a brief note on Cryptozoon and Archæozoon found in the pre-Cambrian. A general discussion is given of the biological affinities of the Cryptozoon and Archæozoon, and descriptions are quoted of younger forms which may be the successors of the pre-Cambrian forms.

Dawson,[3] in an account of the physical geography and geology of Canada, sketches the distribution and characters of the pre Cambrian rocks.

Dawson[4] gives a general account of the pre-Cambrian rocks of Canada. This is largely a discussion of pre-Cambrian classification and nomenclature, based on a review of early and recent work on the pre-Cambrian of Canada, and will, therefore, not be fully summarized. A few of the more important conclusions may, however, be mentioned.

The Laurentian still includes both Fundamental Gneiss and the Grenville series.

[1] Bulletin 86, U. S. Geol. Survey, Pl. V. Sixteenth Ann. Rept., Pl. CVIII.

[2] Note on Cryptozoon and other ancient fossils, by SIR WILLIAM DAWSON: Canadian Record of Sci., Vol. III, pp. 203–219.

[3] The physical geography and geology of Canada, by G. M. DAWSON: Handbook of Canada, issued by the Publishing Committee of the Local Executive of the British Assoc., Toronto, 1897.

This is largely a general summary of the present state of knowledge concerning the geology of Canada, and will therefore not be fully reviewed.

[4] Presidential address to the geological section of the British Association for the Advancement of Science, by G. M. DAWSON: Proc. Brit. Assoc. Adv. Science for 1897, Section C, p. 13

The Huronian proper, under whatever local name it may be classed, still remains a readily separable series of rocks.

The Upper Laurentian, Labradorian, Norian, or anorthosite group is found to consist essentially of intrusive rocks, later in age than the Grenville, but in all probability pre-Paleozoic.

The general tendency in our advance in knowledge appears to be in the direction of extending the range of the Paleozoic downward, whether under the old name of Cambrian, or under some other name, applied to a new system defined, or likely to be defined, by a characteristic fauna; and under Cambrian, or such new system, if it be admitted, it is altogether probable that the Animikie and Keweenawan rocks must eventually be included.

The introduction of the term Algonkian, proposed to include the recognizable sedimentary formations below the Olenellus zone, and their igneous equivalents, is believed to be a backward step, for the following reasons: It detaches from the Paleozoic great masses of conformable and fossiliferous strata beneath an arbitrary plane and unites these under a common systematic name with other vast series of rocks, now generally in a crystalline condition; it includes as a mere interlude, what, in the region of the Protaxis, is one of the greatest gaps known to geological history; and it does not in the least degree remove the difficulty found in defining the base of the Grenville series.

Comment.—The statements that there is a general tendency to extend the term Paleozoic downward as our knowledge advances, and that the introduction of the term Algonkian is a backward step, would not be agreed to by the United States geologists. However, this subject is too complex to be discussed in the space at our disposal. Those interested are referred to Bulletin 86 of the U. S. Geol. Survey, and to the Principles of North American pre-Cambrian Geology in the Seventeenth Annual Report of the U. S. Geol. Survey.

MADISON, WIS. C. K. LEITH.

Reviews

West Virginia Geological Survey. Vol. I. By I. C. White, State Geologist.

The Geological Survey of West Virginia was established, with a small appropriation, by an enactment of the legislature of that state passed in February, 1897. Dr. I. C. White was appointed state geologist and he entered upon the active duties of his office January 1, 1898. The present volume is the first publication of the survey and in it is incorporated a part of the results of investigations prosecuted during 1898.

The report is a paper covered octavo volume of 392 pages and consists of four parts. Part I (pp. 1–26) is a "Report of the State Geological Commission to the Legislature, containing an account of the operations of the survey during the years 1897 and 1898." Part II (pp. 27–53) is entitled "Levels above Tide." It is a compilation of the elevations of the several stations on all the principal railroads of the state, the data for which were contributed by the officers of the roads.

Part III (pp. 54–122) upon the "Variation of the Magnetic Compass" and "True Meridian Lines in the Several Counties of the State" was prepared by R. U. Goode, Geographer, United States Geological Survey in coöperation with the state survey. Meridian monuments were placed in the county seats of each county in the state, and detailed descriptions of the location of the monuments are given in this paper.

The major part of the volume (Part IV, pp. 123–378) is devoted to a report on "Petroleum and Natural Gas" by the state geologist. The report is opened with a historical sketch which is followed by an account of the geology of petroleum and natural gas. A large amount of information which will be of great value to the oil and gas industry of the state is here published.

It is unfortunate that the volume should contain no index, but, as stated by the state geologist, it had to be omitted because of the

lack of sufficient funds. It is to be desired that the State of West Virginia may see fit to continue the work of their geological survey so well begun, by appropriating for it sufficient funds to carry out the work as outlined by the state geologist in Part I of this volume.

S. W.

Recent Publications

—Agassiz, Alexander. The Islands and Coral Reefs of Fiji. Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. XXXIII. With One Hundred and Twenty Plates. Cambridge, Mass., 1899.

—Barrios, Charles. Des Mers Devoniennes de Bretagne et des Ardennes. Extrait des Annales de la Société Géologique du Nord T. XXVII, p. 231, December 1898. Lille.

L'Extension du Silurien Supérieur dans le Pas-de-Calais. Ibid.

Les Goniatites du Ravin du Coulaire (Haute-Garonne). Ibid.

—Bell, Robert. Rising of the Land around Hudson Bay. From the Smithsonian Report for 1897, pp. 359–367, December 1899.

—Broadhead, G. C. Reports on Boone county and the Ozark Uplift. Geological Survey of Missouri, Vol. XII, Part III. Jefferson City, December 1898.

—Communications from the Oxford Mineralogical Laboratory.

I. Mineralogical Notes, Zincblende; Galena, Pyrites; Lead. By Prof. H. A. Miers.

Note on the Crystals of Lead described in the preceding communication. By Allan Dick.

II. On the Constitution of the Mineral Arsenates and Phosphates. By C. G. J. Hartley. Reprinted from the Mineralogical Magazine, Vol. XII, No. 55.

—Darton, N. H. Preliminary Report on the geology and water resources of Nebraska west of the One Hundred and Third Meridian. Extract from the Nineteenth Annual Report. Part IV. Hydrography. Washington, 1899.

—Faribault, E. R., C. E. The Gold Measures of Nova Scotia and Deep Mining. Published by Mining Society of Nova Scotia, December 1899.

—Field Columbian Museum Publications:

Geological Series Vol. I, No. 5. A Fossil Egg from South Dakota. By Oliver Cummings Farrington, April 1899.

Contributions to the Paleontology of the Upper Cretaceous Series. By William Newton Logan.

The Mylagaulidæ, An Extinct Family of Sciurmorph Rodents. By Elmer S. Riggs.

The Ores of Colombia. From Mines in Operation in 1892. By S. E. Meek.

Catalogue of Mammals from the Olympic Mountains, Washington, With Descriptions of New Species. By D. G. Elliot.

Notes on a Collection of Cold-Blooded Vertebrates from the Olympic Mountains. By S. E. MEEK.

Description of Apparently New Species and Sub-Species from Oklahoma Territory. By D. G. ELLIOT. Chicago, 1899.

—FRITSCHE, DR. H. Ueber die Bestimmung der Coefficienten der Gaussischen Allegemeinen. Theorie des Erdmagnetismus für das Jahr 1885 und Ueber den Zusammenhang der drei erdmagnetischen Elemente untereinander. St. Petersburg, 1897.

Die Elemente des Erdmagnetismus für die Epochen 1600, 1650, 1700, 1780, 1842 und 1885 und Ihre Saecularen Aenderungen, etc. St. Petersburg, 1899.

—Geological Survey of New South Wales. Department of Mines and Agriculture. Ethnological Series, No. 1. Aboriginal Carvings of Port Jackson and Broken Bay. Measured and Described by W. D. CAMPBELL, A.K.C., F.G.S. Sydney, 1899.

—HAYES, C. WILLARD. Physiography and Geology of Region Adjacent to the Nicaragua Canal. Bulletin of the Geological Society of America, Vol. 10, pp. 285–348. Rochester, 1899.

—HERRMANN, DR. O. Steinbruchindustrie und Steinbruchgeologie. Berlin, 1899.

—KÜMMEL, DR. H. B. The Newark or Red Sandstone Belt of New Jersey. From the Annual Report of the State Geologist for the year 1897. Trenton, 1898.

—LEVERETT, FRANK. Water Supply and Irrigation Papers of the U. S. Geological Survey No. 21. Wells of Northern Indiana. Ditto No. 26. Wells of Southern Indiana. Washington, 1899.

—LIVERSIDGE, A., M.A., LL.D., F.R.S. The Blue Pigment in Coral. (Heliopora Cœrulea) and other Animal Organisms. Reprinted from Journal and Proceedings of the Royal Society of New South Wales, Vol. XXXII, 1898.

—LORD, EDWIN, C.E.,Ph.D. Petrographic Report of Rocks from the United States-Mexico Boundary. Proc. of the U. S. National Museum, Vol. XXI, pp. 773–782. Washington, 1899.

—MATHEW, W. D. A Provisional Classification of the Fresh Water Tertiary of the West. Extracted from Bulletin of the American Museum of Natural History, Vol. XII, Article II, pp. 19–75. New York, April 1899. (Author's copy.)

—SHALER, N. S. Loess Deposits of Montana. Formation of Dikes and Veins. Spacing of Rivers with Reference to Hypothesis of Base-leveling. Bulletin Geological Society of America, April 1899.

—United States Geological Survey:

Eighteenth Annual Report, 1896–7.

Part I, Director's Report including Triangulation and Spirit Leveling;

Part II, Papers Chiefly of a Theoretic Nature; Part III, Economic Geology; Part IV, Hydrography. Washington, 1899.

—WALCOTT, HON. CHARLES D. Nineteenth Annual Report of the Director of the U. S. Geological Survey to the Secretary of the Interior, 1897–8. Extract, Part I.

Pre-Cambrian Fossiliferous Remains. Bulletin of the Geological Society of America, Vol. X, pp. 199–244, Rochester, April 1899.

The United States Forest Reserves. Reprinted from Appleton's Popular Science Monthly for February 1898.

—WHITE, I. C. Origin of Grahamite. Bull. Geol. Society of America, Vol. X, pp. 277–284, Pl. 29. Rochester, April 1899.